

PB88-172176

Suerfund Record of Decision (EPA Region 8)
Denver Radium Site, Open Space
Properties, Colorado (Seventh Remedial Action)
September 1987

(U.S.) Environmental Protection Agency
Washington, DC

Prepared for

29 Sep 87



U.S. Department of Commerce
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September 1987



Superfund Record of Decision:

Denver Radium/Open Space, CO

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See also PB88-172168. Portions of this document are not fully legible.

The decision document presents the selected remedial actions for the properties included in Operable Units VI, IX, and XI of the Denver Radium Site developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Contingency Plan (40 CFR Part 300). The decision is based upon the administrative record for the Open Space properties, Operable Units VI, IX, and XI of the Denver Radium Site. The attached index identifies the items which comprise the administrative record upon which the selection of the remedial actions was based.

KEYWORDS: *Industrial wastes, *Hazardous materials, *Waste disposal, *Superfund program, *Remedial actions, *Record of decision.

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16. ABSTRACT The Denver Radium site, located in Denver, Colorado, consists of more than 40 contaminated properties. These properties have been grouped into eleven operable units. This operable unit consists of eleven Denver Radium properties in an industrial use area, which are known collectively as Open Space properties. Three of the properties lie within the designated 100-year flood plain. In 1979 EPA noted a reference to the National Radium Institute (NRI) in the 1916 Bureau of Mines report. This reference revealed the presence of 31 radioactive sites in the Denver Metropolitan area. In 1913 the NRI was established in Denver as a domestic source of radium which was in high demand as a wonder drug for the treatment of cancer. Subsequently, the Denver radium, vanadium and uranium industry thrived until the early 1920s when rich deposits of ore were discovered in Africa. Records indicate that one source of contamination at the Open Space properties results from the radium, vanadium and uranium processing conducted by the National Radium Corporation, Radium Company of Colorado, Schlesinger Radium Company and Rocky Mountain Radium Products Company. Additionally the Allied property, a 21.5-acre portion of the Open Space properties site, contains contaminated fill brought in from an unknown construction site in the early 1960s. The Brannan property, a 47.5-acre portion of the site, is suspected to contain radiological hospital waste. Other sources of radioactive materials present at the site have not (See Attached Sheet)				
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DECLARATION
FOR THE
RECORD OF DECISION

Site Name

Open Space Properties
Operable Units VI, IX, and XI
Denver Radium Site

Site Location

Various locations throughout metropolitan area
Denver, Colorado

Statement of Purpose

This decision document presents the selected remedial actions for the properties included in Operable Units VI, IX, and XI of the Denver Radium Site developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Contingency Plan (40 CFR Part 300).

The State of Colorado has concurred on the selected remedies. (See attached letter.)

Statement of Basis

This decision is based upon the administrative record for the Open Space properties, Operable Units VI, IX, and XI of the Denver Radium Site. The attached index identifies the items which comprise the administrative record upon which the selection of the remedial actions was based.

Description of the Selected Remedies

This is the seventh Record of Decision for the Denver Radium Site. The hazardous substances of primary concern that have been released and continue to be released into the environment at the Denver Radium Site properties are radium and its associated decay

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products. Long-term exposure to radium and its decay products has been shown conclusively to increase the risk of contracting lung cancer.

This Record of Decision addresses the contamination present on Operable Units VI, IX, and XI of the Denver Radium Site. Operable Unit VI is comprised of the following properties:

- Allied Chemical and Dye Corporation (Allied)
- Brannan Sand and Gravel (Brannan)
- Colorado and Southern Railroad (CSRR)
- Denver Water Department (DWD)
- Public Service Company (PSCo)
- Ruby Hill Park
- Alley between Mariposa and Lipan Streets

Operable Unit IX includes the International House of Pancakes (IHOP) and Larry's Trading Post and East Side Amusement Center (Larry's). Operable Unit XI consists of the Thomas Real Estate Company (Thomas Realty) property. These properties are known collectively as the Open Space properties. EPA's selected remedy for each of the Open Space properties is described below.

Allied property:

EPA's preferred remedial action alternative for the Allied property is Offsite Permanent Disposal. However, until a facility suitable for permanent disposal of the Open Space properties material is designated and, if necessary, acquired and developed, this alternative cannot be implemented. Pursuant to CERCLA Section 104(c)(3)(C)(ii), it is the responsibility of the State of Colorado to assure the availability of a facility for offsite disposal of the Open Space properties material. Although both the EPA and State of Colorado are continuing to seek a permanent disposal site, the State estimates that this process could take up to five years. Given the length of time which may pass before the State assures the availability of an offsite permanent disposal facility, and in order to prevent or minimize the threat to public health and the environment, the EPA has determined that a remedial action alternative which includes temporary response actions should be implemented at the Allied property.

EPA has therefore determined that the appropriate extent of remedy at the Allied property is Onsite Temporary Containment (Capping), Offsite Permanent Disposal. This remedial action alternative will attain a degree of cleanup of the hazardous substances which will assure both short-term and long-term protection of human health and the environment. The present-worth cost of the selected remedy for the Allied property is \$143,600 based upon a ten-percent interest rate, a five-year discount period, and a perpetual monitoring period. The selected remedial action alternative for the Allied property entails:

- placing a cap over the identified areas of contamination which cover approximately 4,320 square feet of the Allied property;
- maintaining the cap on the Allied property until a facility suitable for the permanent disposal of Open Space properties material becomes available; and
- excavating the contaminated material from under the cap and transporting the material to the offsite permanent disposal facility.

Remedial Design for the Allied property will include the selected remedy and EPA's preferred remedial action alternative, Offsite Permanent Disposal. Should the State of Colorado fulfill its obligation to assure the availability of a suitable disposal facility for material from the Open Space properties by the time EPA has concluded Remedial Design for the Allied property, the EPA may implement its preferred alternative, Offsite Permanent Disposal.

Brannan property, Ruby Hill Park, and the Alley:

EPA's selected remedy for the Brannan property, Ruby Hill Park and the alley is No Action. According to the Remedial Investigation, it does not appear that the radium contamination in soils on these properties exceeds the target residual levels established in contaminant-specific ARARs for the Open Space properties. None of these properties would be eligible for cleanup under the inclusion criteria developed to implement the contaminant-specific ARAR, 40 CFR Part 192.

In the case of the alley, EPA makes the following recommendations:

1. That the City and County of Denver improve existing institutional controls so that all routine maintenance, repair, or construction activities in the alley carried out by government agencies, utility companies, contracting companies, private individuals, etc., will be monitored; and
2. That the City and County of Denver consider removing or requiring the removal of any contaminated material excavated during routine maintenance, repair, or construction activities in the alley to a facility approved for the storage or disposal of such contaminated material.

EPA believes these recommendations will more successfully be carried out if the alley is included in the institutional controls program for Streets, Operable Unit VII of the Denver Radium Site. The City and County of Denver is developing these institutional controls under a cooperative agreement with the State of Colorado. EPA has already awarded Superfund Cooperative

Agreement funds for this purpose and consistent with CERCLA Section 104(c)(3), the State of Colorado and the City and County of Denver will be responsible for assuring the payment of all future costs of maintaining and operating the institutional controls, including proper disposal of any contaminated material excavated during routine maintenance, repair, or construction activities in the alley.

Data on the Brannan property, Ruby Hill Park, and the alley will be reviewed during Remedial Design of the Open Space properties, and if necessary, additional data will be collected to confirm that the target residual levels are not being exceeded. If EPA determines that the costs of additional sampling for this purpose would exceed the costs of cleanup, or if the review indicates that target residual levels are exceeded, a remedial action alternative other than No Action may be implemented at these properties.

In the case of the Brannan property and the alley, Onsite Temporary Containment (Capping), Offsite Permanent Disposal, will serve as the backup alternative. If future data evaluation indicates that contaminant-specific ARARs are being exceeded at Ruby Hill Park, or if the costs of additional sampling to make a determination exceed the costs of cleanup, then Temporary Building Storage at Card Corporation Property (OU X), Offsite Permanent Disposal, will be implemented at the Park.

The present-worth cost of the selected remedy for Ruby Hill Park depends upon whether future data evaluation indicates that contaminant-specific ARARs are exceeded, resulting in the backup alternative being implemented. If instead of No Action, Temporary Building Storage at Card Corporation Property (OU X), Offsite Permanent Disposal, is implemented at Ruby Hill Park, the present worth cost would be \$92,900.

The present worth cost of the selected remedy for the Brannan property and the alley depend upon whether future data evaluation indicates that contaminant-specific ARARs are exceeded, resulting in the backup alternatives being implemented. If instead of No Action, Onsite Temporary Containment (Capping), Offsite Permanent Disposal, is implemented at the Brannan property, the present worth cost would be \$68,500. If this remedial action alternative is implemented at the alley, the present-worth cost would be \$41,000.

CSRR, DWD, PSCO, IHOP and Larry's, and Thomas Realty properties:

The EPA preferred alternative for these properties is Offsite Permanent Disposal. However, as described above, until a facility suitable for permanent disposal of the Open Space properties material is designated and, if necessary, acquired and developed by the State of Colorado, this alternative cannot be implemented. EPA has therefore determined that the appropriate extent of remedy for these properties is Temporary Building

Storage at Card Corporation Property (OU X), Offsite Permanent Disposal. This remedial action alternative will provide both short-term and long-term protection of public health and the environment.

The selected remedial action alternative for the CSRR, DWD, PSCo, IHOP and Larry's, and Thomas Realty properties entails:

- cleanup of these properties and storage of the contaminated material from these properties in the temporary storage facility on the Card Corporation property, Operable Unit X of the Denver Radium Site;
- maintaining the temporary storage facility at the Card Corporation property until a facility suitable for the permanent disposal of Denver Radium Site wastes becomes available; and
- final removal of the contaminated material from the Card Corporation property and transport to the offsite permanent disposal facility.

The present worth cost of the selected remedy for these properties is as follows:

CSRR	\$126,800
DWD	150,600
PSCo	94,000
IHOP	130,700
Larry's	93,600
Thomas	147,600

The costs are based upon a ten-percent interest rate, a five-year discount period, and a perpetual monitoring period.

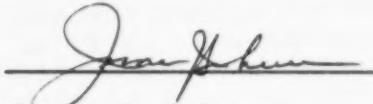
Remedial Design for these properties will include the selected remedy and EPA's preferred remedial action alternative, Offsite Permanent Disposal. Should the State of Colorado fulfil its obligation to assure the availability of a suitable disposal facility for material from the Denver Radium Site by the time EPA has concluded Remedial Design for these properties, the EPA may implement its preferred alternative, Offsite Permanent Disposal.

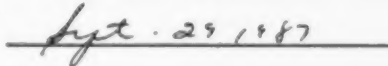
Operation and maintenance activities will be required to ensure the effectiveness of the temporary response actions associated with the selected remedies for the Open Space properties. These activities include site inspections, ongoing radiological monitoring, and possible minor repairs to the cap on the Allied property or the temporary storage facility on the Card Corporation property. Also included as an operation and maintenance activity for cost estimating purposes is a review of the properties which, pursuant to SARA Section 121(c), must be conducted no less than every five years if a remedial action is selected that results in any hazardous substances remaining

onsite. Since EPA does not anticipate that any hazardous substances will remain onsite longer than five years, the cost of this review is considered a contingency. Operation and maintenance costs for each property are included with the present worth total alternative costs mentioned above.

Declarations

Consistent with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Contingency Plan (40 CFR Part 300), I have determined that the selected remedies for the Open Space properties, Operable Units VI, IX, and XI of the Denver Radium Site, are protective of human health and the environment, attain Federal and State public health and environmental requirements that are applicable or relevant and appropriate, and are cost-effective. The remedies utilize permanent solutions and alternative treatment technologies to the maximum extent practicable. Even though the remedies do not satisfy the statutory preference for treatment which reduces the toxicity, mobility, and volume of hazardous substances as its principal element, the remedies address the principal threat at the properties. Treatment was determined to be impracticable based upon effectiveness, technical feasibility, implementability, and cost factors.


James J. Scherer
Regional Administrator
EPA Region VIII


Date

RECORD OF DECISION SUMMARY

Site Name

Open Space Properties
Operable Units VI, IX, and XI
Denver Radium Site

Site History

Shortly after radium was discovered by Marie Curie in 1898, it gained enormous popularity as the miracle remedy for a wide variety of ailments, especially cancer. Consequently, the demand for the element increased dramatically through the early 1900s.

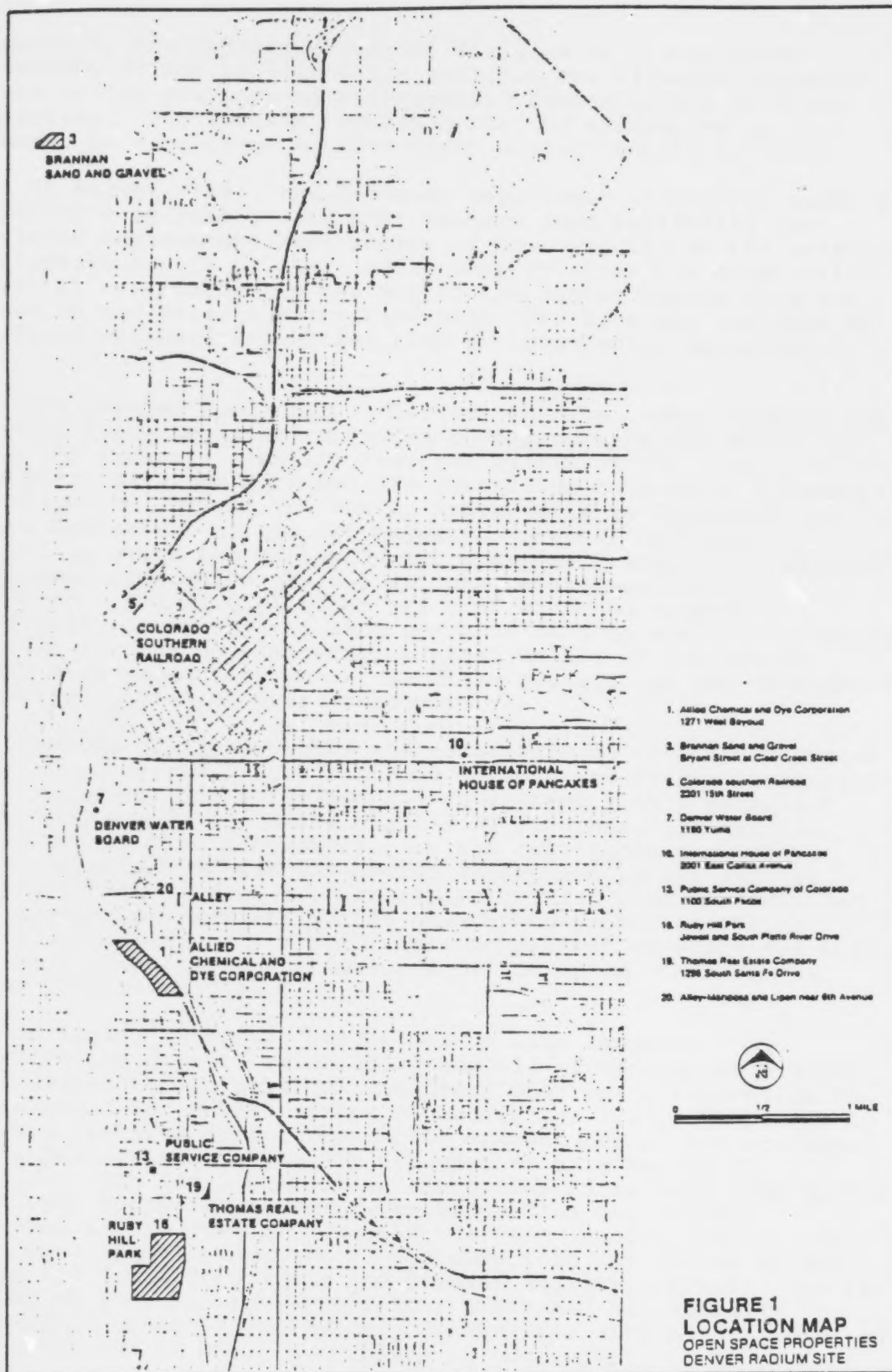
Prior to 1914, the processing of radium-bearing ore was conducted exclusively in Europe. The onset of World War I, however, caused a growing concern in the United States that European exportation of radium might be interrupted. This concern led to the establishment of the National Radium Institute in 1913. The National Radium Institute successfully developed and operated a radium processing plant in Denver.

Denver was chosen as the location of the National Radium Institute facility due to its proximity to the Colorado Plateau, which contained rich deposits of the radium-bearing ore, carnotite. Soon numerous operations opened in Denver to process ore for radium, vanadium, and uranium. However, during the early 1920s, the availability of less expensive radium from foreign countries forced most of the Denver producers to abandon their operations.

Much of the radiological contamination present on the Open Space properties, Operable Units VI, IX, and XI of the Denver Radium Site, is believed to be either the direct result of radium and uranium processing on the property or the result of processing wastes being transported to the property from a processing site.

Response History

In 1979, EPA noted a reference to the National Radium Institute in a 1916 United States Bureau of Mines report. Subsequent field research revealed the presence of thirty-one radioactive sites in the Denver metropolitan area, several of which are now part of the Open Space properties of the Denver Radium Site (Figure 1). Immediately after identifying these



properties, the Radiation Control Division of the Colorado Department of Health officially notified the affected property owners of the presence of radiological contamination on their properties. The letters requested that no excavation or soil movement be undertaken without first contacting the Division.

In August, 1981, the Colorado Department of Health, under a cooperative agreement with EPA, assumed lead activities and initiated engineering assessments of the majority of the original 31 properties. In October, 1981, shortly after the cooperative agreement was awarded to the State, the Denver Radium Site was placed on the Interim Priorities List. The Site was included on the Final National Priorities List promulgated on September 8, 1983.

EPA resumed Fund-lead activities in June, 1983, because the Colorado State Legislature failed to appropriate the state cost share for remedial planning required by EPA at the time. In December, 1983, EPA directed its contractor to conduct a Remedial Investigation (RI) of the Denver Radium Site to determine the nature and extent of the contamination present on those properties which the State did not previously study plus several contiguous properties where additional contamination was suspected. EPA also directed its contractor to conduct a Feasibility Study (FS) of each operable unit to evaluate proposed remedies for the contamination present on all of the Denver Radium Site properties which, with the addition of the contiguous properties, totalled over 40 properties.

Because of the enormity and complexity of the Denver Radium Site, EPA determined that response actions undertaken in operable units would be cost-effective and consistent with a permanent remedy for the entire Denver Radium Site. Thus, the original Denver Radium Site properties plus the contiguous properties where contamination was discovered subsequent to the initial listing of the site on the Interim Priorities List were divided into eleven operable units, the Open Space properties being Operable Units VI, IX, and XI. The properties were divided based primarily upon site conditions and proximity to other Denver Radium Site properties.

In April, 1986, the Denver Radium Site Remedial Investigation Report, which addresses all eleven operable units, was released to the public. The draft Open Space Properties FS was released for public review on August 14, 1987. Responses to comments received during the public comment period are contained in the Responsiveness Summary attached to this Record of Decision. The final Open Space Properties FS is comprised of the draft Open Space Properties FS incorporating the changes described in the errata. Pursuant to SARA Section 104(i), the draft Open Space Properties FS was submitted for review by the Agency for Toxic Substances and Disease Registry (ATSDR). At the signing of this Record of Decision, ATSDR had not formally responded. However, preliminary discussions with ATSDR indicated that ATSDR had no major criticisms of the report.

Site Location and Description

The Denver Radium Site, located in Denver, Colorado, (population 509,000) consists of more than 40 contaminated properties. These properties have been grouped into operable units. Operable Unit VI is comprised of the following properties:

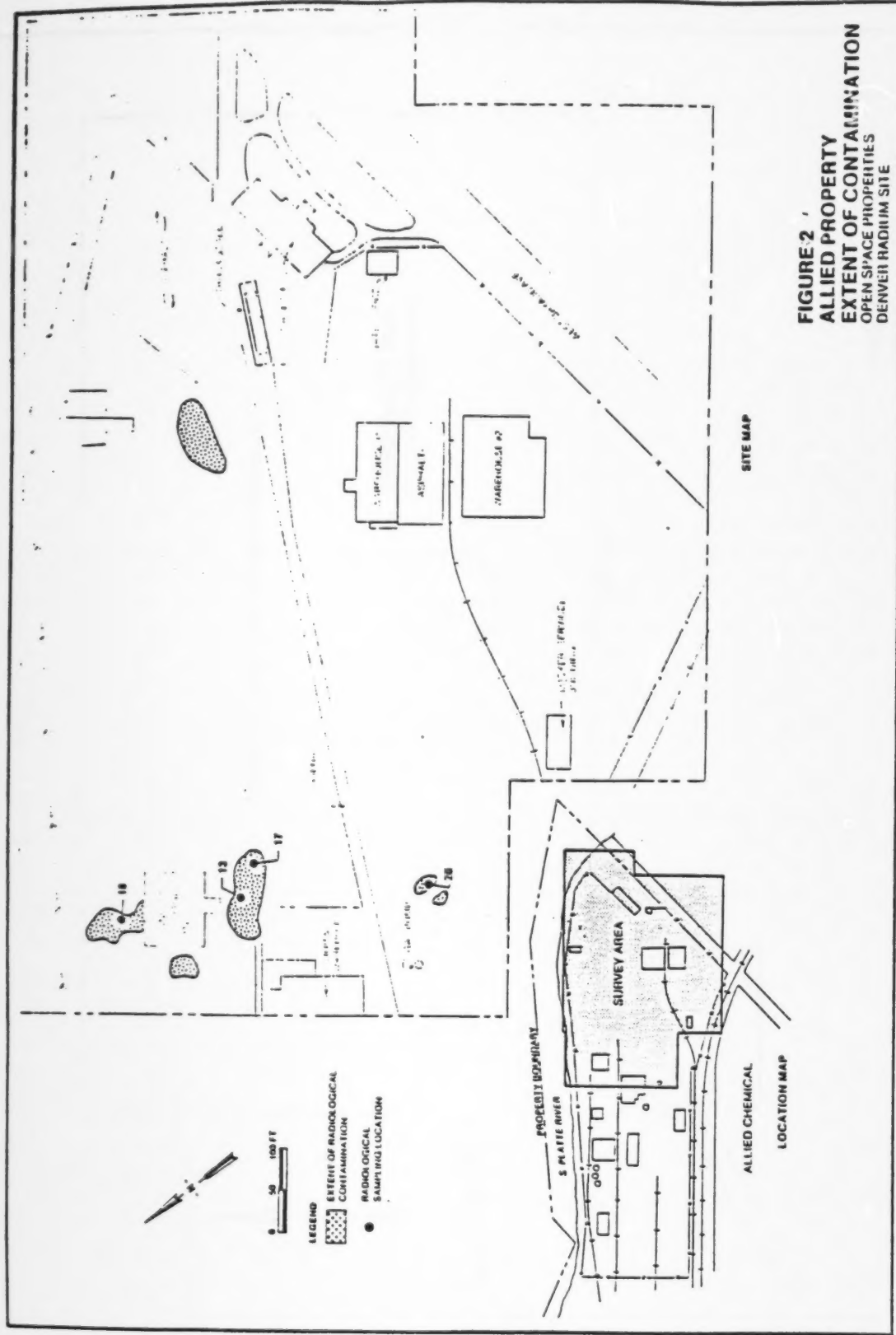
- Allied Chemical and Dye Corporation
- Brannan Sand and Gravel
- Colorado and Southern Railroad
- Denver Water Department
- Public Service Company
- Ruby Hill Park
- Alley between Mariposa and Lipan Streets

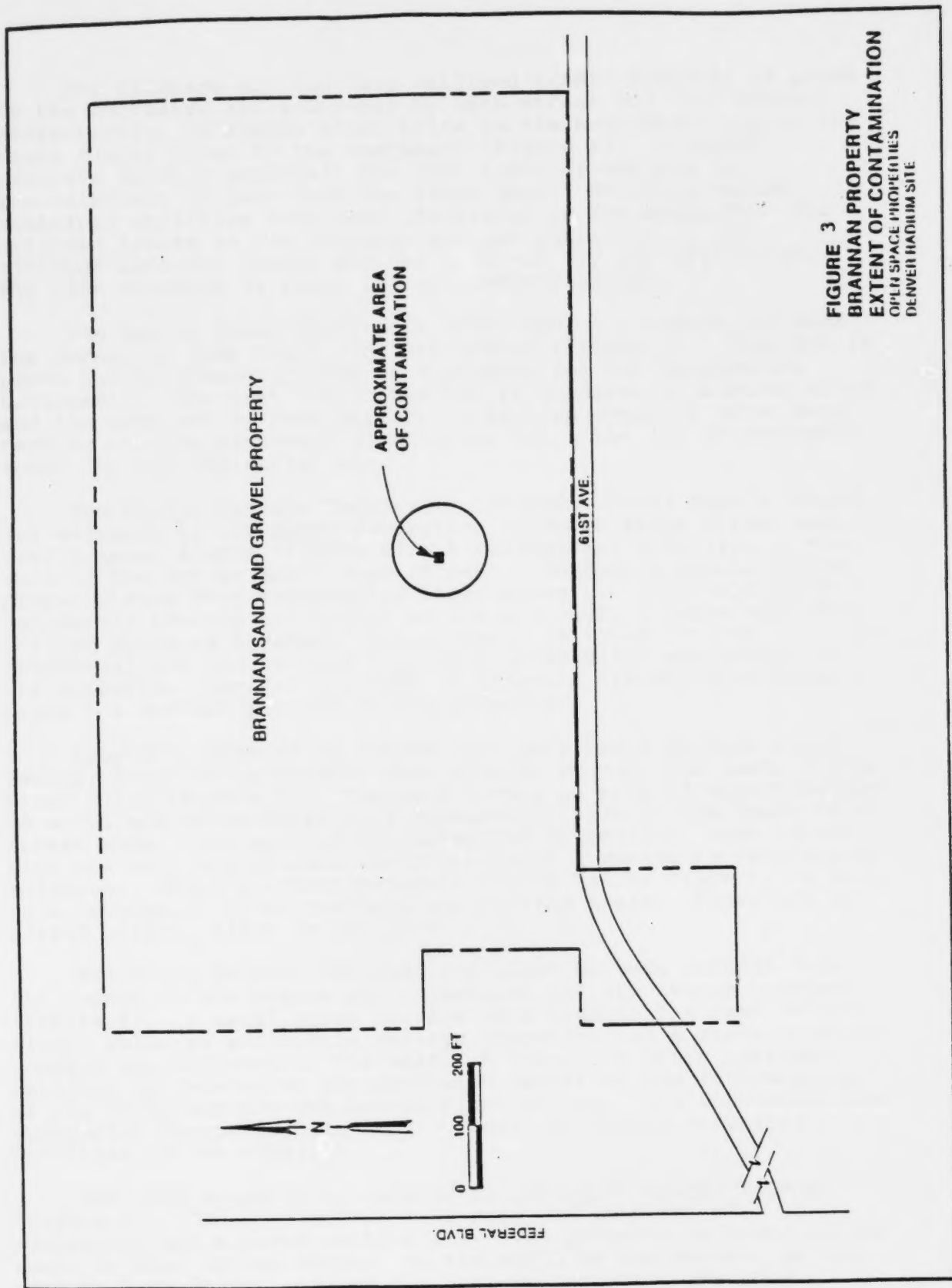
Operable Unit IX includes the International House of Pancakes (IHOP) and Larry's Trading Post and East Side Amusement Center (Larry's). Larry's is a contiguous property sometimes referred to as Contiguous Property No. 8 (CP No. 8). Operable Unit XI consists of the Thomas Real Estate Company (Thomas Realty) property. These properties are known collectively as the Open Space properties.

Since the RI was initiated, ownership of several of the properties has changed. The Allied Chemical and Dye Corporation property is currently owned by General Chemical, the Colorado and Southern Railroad property is presently owned by Burlington Northern Railroad, and the Thomas Realty property is now owned by Commercial Investors Realty. For the purpose of this Record of Decision, however, the original names will be used.

The Allied Chemical and Dye Company (Allied) property covers an area of 21.5 acres and is located at 1271 West Bayaud Avenue. The property is bound on the northeast by the South Platte River, on the southwest by a railroad, and on the south by West Bayaud Avenue. The north end of the property is leased to Denver Wood Products (Figure 2). The Allied property is primarily open land with occasional trees, roadways, railroad tracks, and paved areas. There are approximately ten structures onsite and currently nine employees working 40 hours per week on the property. There are no buried municipal utilities in contaminated areas of the site, although 13 kilovolt overhead lines are present along the northern and northwestern perimeters of the property. The property is zoned I-1 for industrial use.

The Brannan Sand and Gravel (Brannan) property is a 47.5-acre parcel that lies between Clear Creek and 61st Avenue about 300 feet east of Federal Boulevard (Figure 3). The property contains approximately 10 acres of open land which became a municipal dump in the early 1960's. When the dump was closed in 1982, it contained 10 to 15 feet of refuse and was being covered with construction debris. The Brannan property is currently zoned I-1 for industrial use. There are no buried municipal utilities on the property.





The Colorado and Southern Railroad (CSRR) property is bound to the northeast and southwest by 16th Street and 15th Street, respectively, by Platte River Drive to the northwest, and by the South Platte River to the southeast (Figure 4). A buried concrete conduit parallels the CSRR right-of-way and is approximately 50 feet from the river bank. No other buried municipal utilities have been identified on the property. The railroad tracks on the property are not currently in use, although both the tracks and the right-of way are maintained. The CSRR property is zoned I-1 for industrial use.

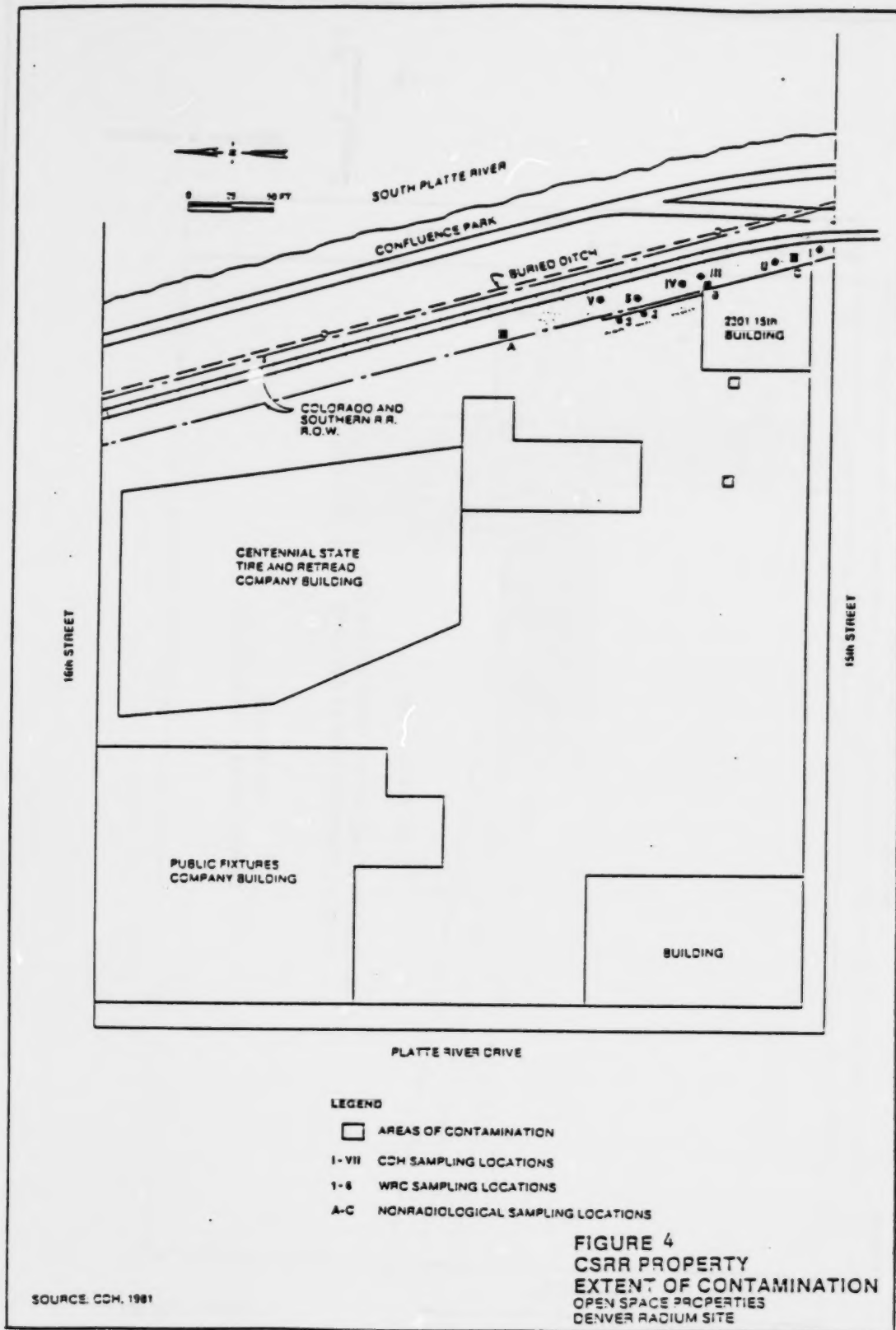
The Denver Water Department (DWD) owns a 0.1-acre lot near the corner of Yuma Court and 12th Avenue (Figure 5). This lot is paved and is presently used as a parking lot for neighboring businesses. The east end of the lot is bordered by a paved alley and the west end by Yuma Street. A 54-inch concrete water main trending roughly east-west bisects the lot. The lot is currently zoned I-1 for industrial use.

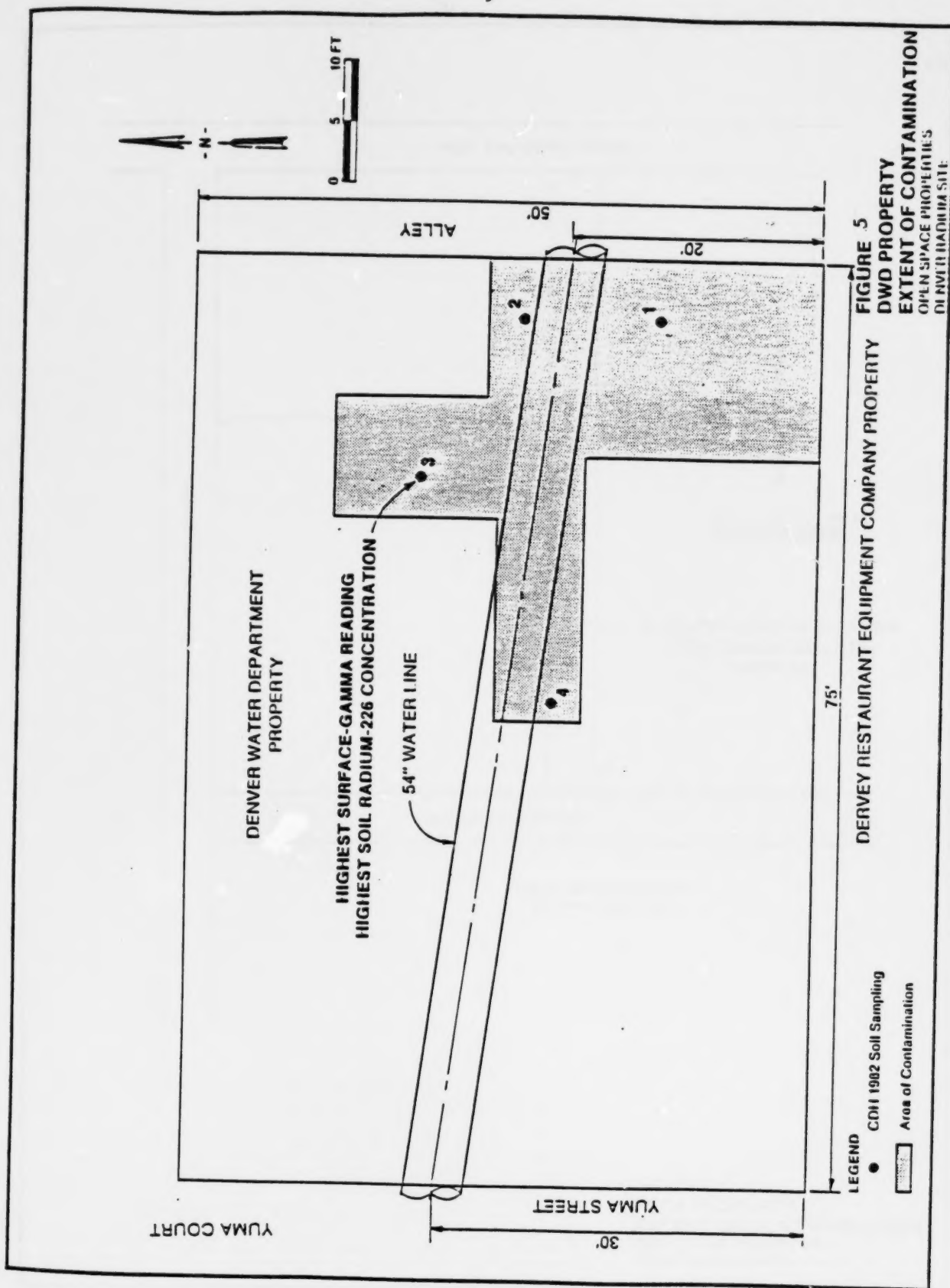
The Public Service Company of Colorado (PSCo) owns a vacant lot adjacent to its South Substation at south Pecos Street and West Arizona Avenue (Figure 6). A residential area lies to the west of the lot on South Pecos Street. Surface drainage on the property runs from topographic highs along the north and south boundaries towards the center of the lot where a large east-west trending gully is located. The property is zoned I-1 for industrial use and several four-inch water mains are buried on the property. Several overhead 13 kilovolt transmission lines cross the western portion of the property.

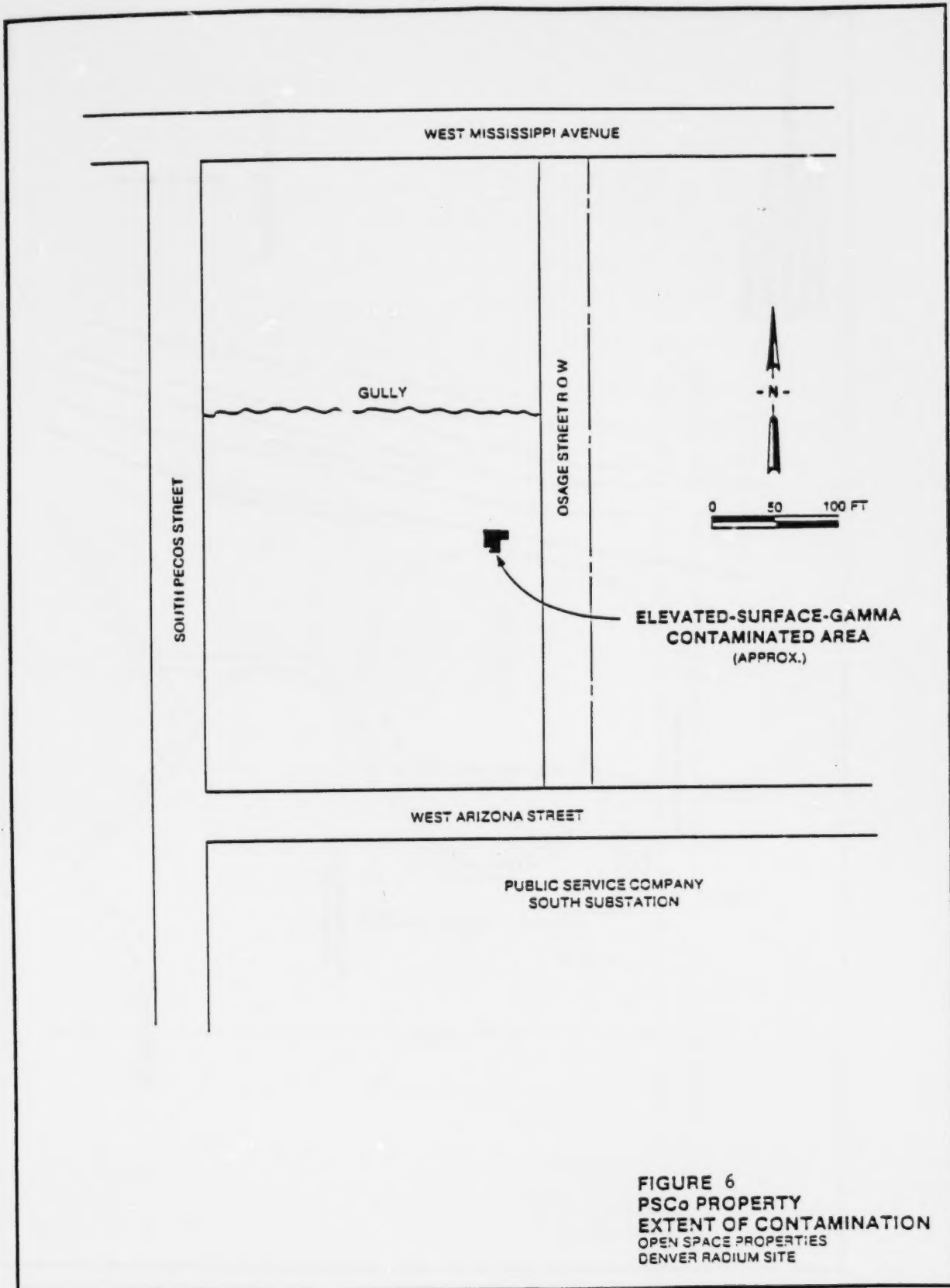
Ruby Hill Park is an active city park bound by West Jewell Avenue, South Pecos Street, West Florida Avenue, and South Platte River Drive (Figure 7). The park covers an area of approximately 90 acres and is bordered by a residential area on the South Pecos Street side. The park is characterized by rolling, open terrain with the only significant structure being a one-story maintenance building. There are four baseball fields on the property as well as a network of paved roadways and parking areas. There are no buried utility lines in the park.

The alley between Mariposa and Lipan Streets extends from 5th Avenue to 6th Avenue and underneath the 6th Avenue overpass (Figure 8). A metal scrap storage yard lies to the east of the alley, while an automobile salvage operation and a stove products company are situated to the west. A one-story brick apartment building is located at the northeast corner of the intersection of the alley and the 6th Avenue right-of-way. The apartments are unoccupied except for one unit. There are buried municipal utilities in the alley.

The IHOP property is located at 2001 East Colfax Avenue (Figure 9). The site covers 0.38 acre and consists of a restaurant and a paved parking lot. The property is bound on the south by East Colfax Avenue, on the north by residences, on the west by Race Street, and on the east by Larry's. The IHOP







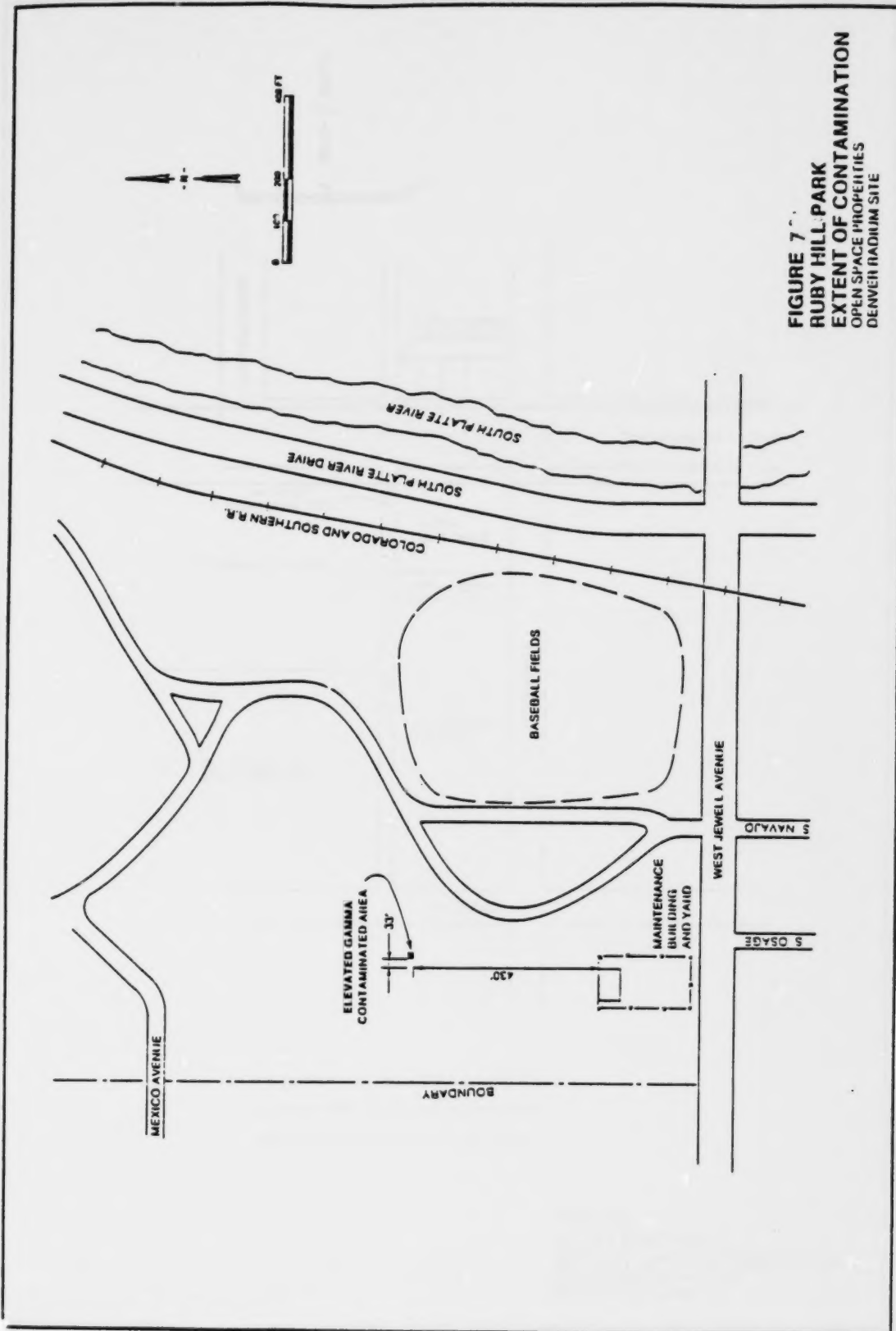


FIGURE 7
RUBY HILL PARK
EXTENT OF CONTAMINATION
 OPEN SPACE PROPERTIES
 DENVER RADIIUM SITE

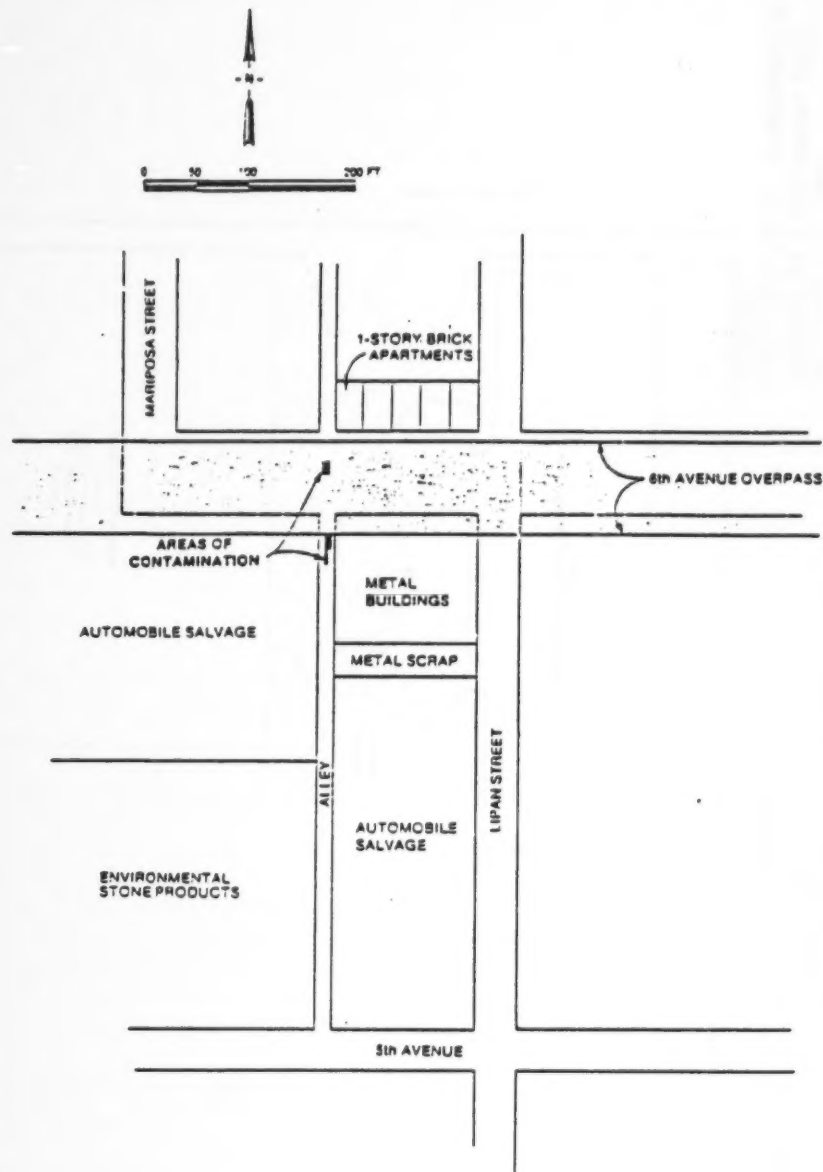
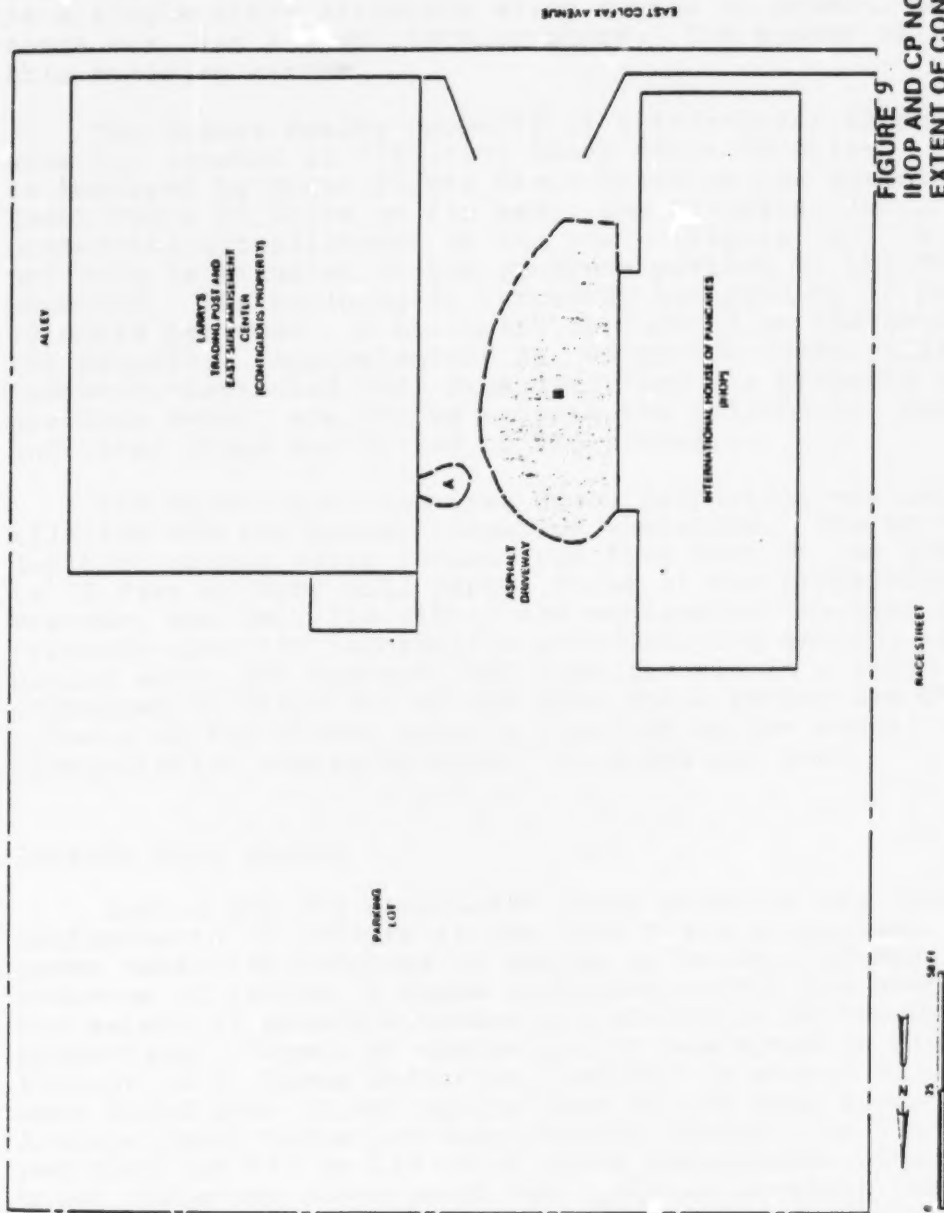


FIGURE 8
 ALLEY PROPERTY
 EXTENT OF CONTAMINATION
 OPEN SPACE PROPERTIES
 DENVER RADIUM SITE



restaurant is a two-story building that operates 24 hours a day. The restaurant employs approximately 15 people who are divided into three work shifts. Buried water lines are present on the IHOP property and the property is zoned B-4 for general business use. Larry's, which shares a driveway and parking lot with IHOP, is a single-story structure which houses an arcade, pool hall, snack bar, and a used clothing store. The number of occupants of this building varies.

The Thomas Realty property is a triangular shaped, 1.25-acre lot located at 1285-1295 South Santa Fe Drive. The property is bordered by South Platte River Drive on the northwest, by South Santa Fe Drive on the east, and by Desks, Inc., a commercial establishment on the south (Figure 10). A two-story, building is situated on the southern portion of the Thomas property. The building is currently occupied by 13 people for 40 hours per week. A billboard is located on the northern end of the property. Approximately 30, 30-gallon drums, filled with radium-contaminated soil excavated from the property by the previous owner, are stored beneath the billboard. Natural gas and water lines are buried on the property.

The majority of the Open Space properties are underlain by alluvium and the Denver formation sandstone. The approximate depth to ground water ranges from five feet at the DWD property to 75 feet at Ruby Hill Park. Three of the properties, Allied, Brannan, and DWD, lie within the designated 100-year flood plain. Property-specific information on underlying geology, depth to ground water and bedrock, and location within a flood plain is contained in Table 2-1 of the Open Space Properties FS. The climate of the Denver area is typified by low annual precipitation averaging about 14 inches per year.

Current Site Status

Radium and its associated decay products are the primary contaminants of concern at the Open Space properties. Since gamma radiation readings in excess of background may indicate the presence of radium, a gamma radiation survey was used to outline the extent of possible radium contamination on the Open Space properties. (Areas of contamination are noted on Figures 2 through 10.) Gamma radiation readings in excess of background were found over 16,902 square feet of the Open Space properties. Average gamma radiation measurements ranged from 7 microrentgen per hour ($\mu\text{R/hr}$) to 239 $\mu\text{R/hr}$ above background. The maximum gamma radiation measurement was 1,900 $\mu\text{R/hr}$ above background and was taken at the CSRR property. (A general discussion of radiation and its associated units of measurement is presented in Appendix A of the Open Space Properties FS and in the Public Health and Environmental Assessment, Appendix B of the Open Space Properties FS.)

The presence of radium in the soil was verified by radiochemical analysis of subsurface soil samples from each of

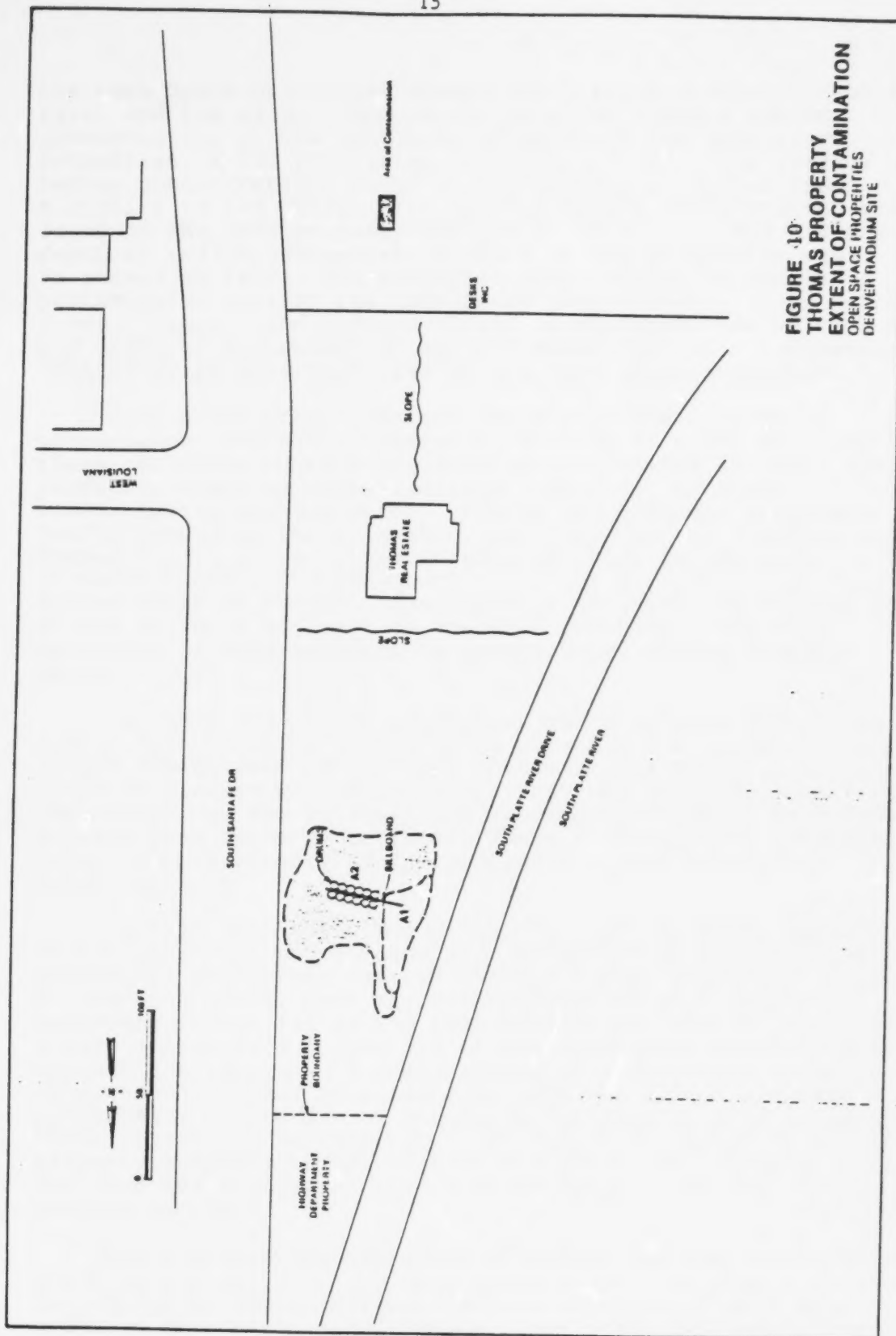


FIGURE 10
THOMAS PROPERTY
EXTENT OF CONTAMINATION
OPEN SPACE PROPERTIES
DENVER RADIUM SITE

the Open Space properties except the Brannan property, Ruby Hill Park, and the alley. The volume-weighted average radium concentration in the contaminated soils on the Open Space properties is 101 picocuries per gram (pCi/g). The average radium concentrations found on the properties ranged from 8.2 pCi/g to 244 pCi/g. The maximum radium concentration was found on the CSRR property and was 2,775 pCi/g. The maximum depth of radium contamination found on the properties was 56 inches at IHOP. The estimated total volume of radium contaminated soil on the Open Space properties is 1,380 cubic yards. Table 1 and Figures 11 and 12 summarize the volume, area, and depth of contamination and the gamma radiation and radium concentration data collected on the Open Space properties.

Only a few structures are present on the Open Space properties. EPA has no reason to suspect that the majority of these buildings contain elevated concentrations of radon decay products, elevated gamma radiation readings, or alpha radioactivity contamination. EPA or the Colorado Department of Health conducted tests in IHOP, Larry's, and the building on the Thomas Realty property and determined these buildings to be free of contamination. These conclusions are subject to verification during Remedial Design. The State of Colorado was refused entry to the building adjacent to the CSRR property. EPA will determine if this building is contaminated during Remedial Design.

On those Open Space properties where samples were taken, the radium concentration in the soils exceeded the target residual levels established in the "EPA Standards for Remedial Actions at Inactive Uranium Processing Sites," 40 CFR Part 192, which EPA has determined are relevant and appropriate Federal requirements for the Open Space properties. These standards are discussed later in this summary in the section entitled "Statutory Determinations".

Certain Open Space properties, Allied and CSRR, were investigated for nonradiological contamination because of known historical industrial uses of the particular property. Figures 2-3 and 2-5 of the Open Space Properties FS show sampling locations on the Allied and CSRR properties, respectively, and Tables 2-4, 2-5, 2-8, and 2-9 of the Open Space Properties FS present the results. A small number of polynuclear aromatic hydrocarbons (PAHs) were found on both the Allied and CSRR properties. There are no standards for PAHs in soil to which these levels can be compared. One sample collected on the Allied property exceeded the Extraction Procedure (EP) toxicity limits for lead and mercury as specified in Table 1, 40 CFR Section 261.24.

The elevated concentration of radium and the uncontrolled state of the soils on the Open Space properties pose a health hazard due to three principal potential exposure pathways. In order of decreasing significance, they are: (1) inhalation of radon gas, the immediate decay product of radium, and radon's own

Table 1

SURFACE AND SUBSURFACE CONTAMINATION
OPEN SPACE PROPERTIES, DENVER RADON SITE

Location	Volume (yd ³)	Area (ft ²)	Gamma Radiation ^a (μ R/hr)		Estimated Depth (in.)	Radon Concentration (pCi/g)	
			Average	Maximum		Average	Maximum
Allied	293	4,320	119	275	18 20 22	34 198 136	34 198 136
Brannan	11	200	60	107	18	NA	NA
CSRR	207	2,800	231	1,900	24	243.5	2,775
EWD	309 ^b	1,500	239	800	NA	8.2	18.7
PSCo	18	325	NA	NA	0-18	37	54
Ruby Hill	10 ^{+b}	4	51	51	NA	NA	NA
Alley	NA	125	29	29	NA	NA	NA
CP No. 8 (A)	11	100	7	8	36	112.6	425.5
IEOP (B)	198	1,145	12	62	0-56	17.2	74.1
Thomas (A ₁)	128	1,151	31	76	36	212.5	690
Thomas (A ₂)	194	5,232	15	83	12	79.1	113
TOTAL	1,379	16,902			Max: 56		

^aValues converted for purpose of comparison. These values are less accurate than those presented in Table 2-2, as assumptions were made in conversions.

^bEstimated volume; no depth value obtained for this area.

Notes: NA = Data not available or not recorded for this area.

Maximum gamma is maximum grid scan gamma. Gamma readings are corrected readings above background (approximately 15 μ R/hr for the Denver area).

Areas given are based on elevated gamma readings. Volumes are calculated using depths from the 1982 CDH study, except for the Thomas property, which used depths from the 1985 EPA study, and the IEOP and CP No. 8 properties, where the area of contamination was defined using both the 1982 CDH study and the 1985 EPA study. Where a range of depths is given, the maximum depth is used to calculate the volume. If a volume is given with depth not available, the volume has been taken directly from the CDH study. The rationale for the volume for Ruby Hill is presented in the text.

Locations of contamination can be found in Figures 2-2 through 2-15.

Figure 11

AVERAGE AND MAXIMUM GAMMA RADIATION MEASUREMENTS
OPEN SPACE PROPERTIES
DENVER RADIUM SITE

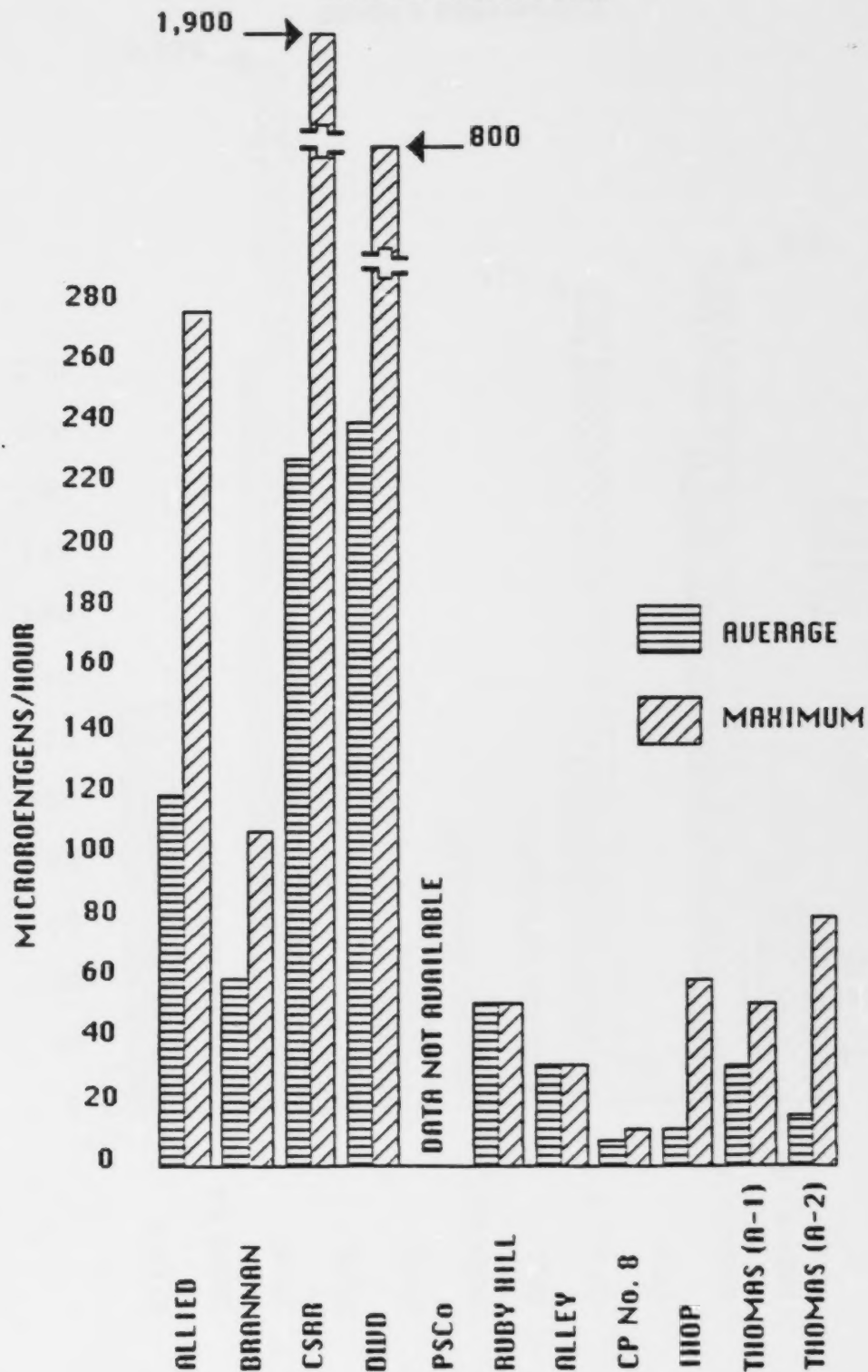
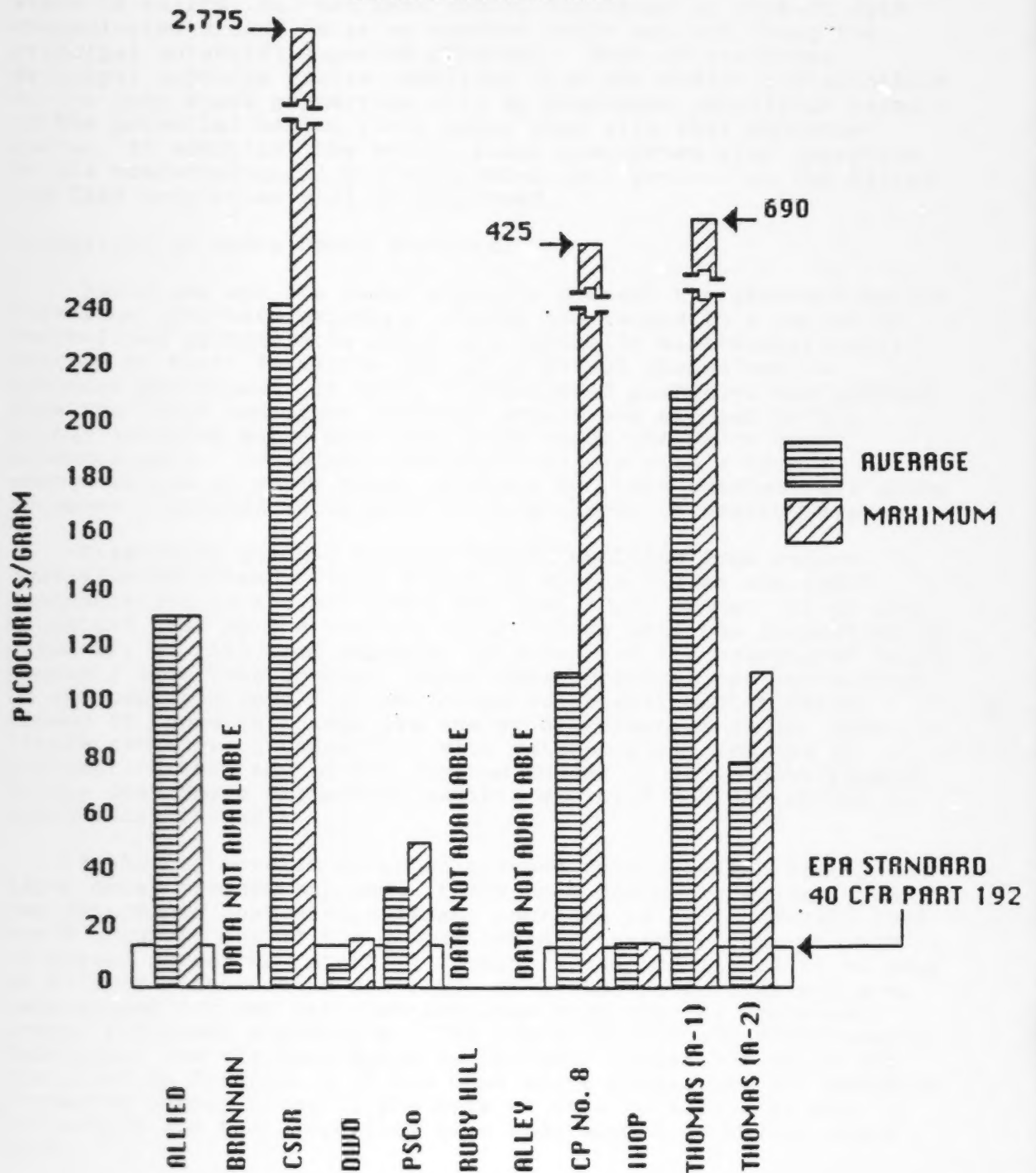


Figure 12

AVERAGE AND MAXIMUM RADIUM CONCENTRATIONS
OPEN SPACE PROPERTIES
DENVER RADIUM SITE



short-lived decay products, (2) direct gamma radiation exposure from the decay of radium and its progeny, and (3) ingestion or inhalation of radium-contaminated materials. Since radium is in a form that is relatively insoluble, and since migration of radiological contaminants into the ground water or surface water, where it exists, has not been noted, ingestion or contact with contaminated ground water or surface water are not among the principal potential exposure pathways. Each of the three principal exposure routes resulting from the radium contamination on the Open Space properties will be discussed briefly in terms of the potential health risks associated with that exposure route. In addition, the health risks associated with ingestion of the nonradiologically contaminated soil present on the Allied and CSRR properties will be discussed.

Inhalation of Radon Decay Products:

Radon gas and its decay products present the greatest health risk from long-term exposure. Radon gas decays to a series of short-lived particulates which are typically electrostatically charged at their formation and often attach themselves to airborne particles. If these contaminated particles are inhaled, then the lungs and other internal organs are exposed to the highly ionizing sub-atomic particles which the radon decay products emit. Prolonged inhalation of air with a high concentration of radon decay products has been conclusively shown to cause increased occurrence of lung cancer in uranium miners.

Dispersion quickly dilutes radon emanating from radium-contaminated ground. This mechanism will minimize the radon concentration in the air above the Open Space properties to such an extent that no one working on or living near the properties is presently at risk from exposure to radon and its associated decay products from this source. Radon decay products can concentrate to unacceptable levels in buildings built over contaminated ground if those buildings are energy efficient, that is, have little exchange of indoor air with outdoor air. EPA has no information that any of the limited number of structures present on the Open Space properties exhibit elevated concentrations of radon decay products.

Although there is no known present public health risk from radon decay product exposure at the Open Space properties, EPA has determined that a significant increase in public health risk would occur if any of the contaminated material on the properties is spread closer to potential receptors, especially if it is used as fill or construction material, or if the properties are ever redeveloped for any use that involves occupancy in enclosed, energy-efficient structures. The Public Health and Environmental Assessment for the Open Space properties, summarized below and contained in Appendix B of the Open Space Properties FS, presents projected cancer risks if EPA were to take no action at the properties and the properties were redeveloped in any of these ways.

If a building were constructed over the CSRR property, the most contaminated of the Open Space properties, and several conservative assumptions are made (such as lifetime exposure), the estimated radon decay product concentration in such a building would average 1.46 WL. The radon decay product concentration in a typical United States home is 0.005 WL and the relevant and appropriate EPA standard, 40 CFR Part 192, is 0.02 WL. The average projected cancer risk (excluding background) to individuals working in such a building ranges from 1,400 to 4,200 cancer deaths per 10,000 persons exposed. The average projected cancer risk to individuals living in such a building ranges from 4,700 to 7,800 cancer deaths per 10,000 persons exposed.

These risk values can be compared to the average projected cancer risk if the radon decay product concentration in the building was 0.02 WL, the EPA standard. In this case, the average projected cancer risk to individuals working in such a building ranges from 23 to 91 cancer deaths per 10,000 persons exposed. The average projected cancer risk to individuals living in such a building ranges from 130 to 500 cancer deaths per 10,000 persons exposed. If the radon decay product concentration in the building was that of a typical United States home, 0.005 WL, then the average projected cancer risk to individuals living in the building would range from 33 to 130 cancer deaths per 10,000 persons exposed. It should be noted that these projected cancer risk numbers do not include the EPA-estimated spontaneous risk of lung cancer, that is, the risk not attributable to either smoking or radon. Table 2 presents the information stated above.

Gamma Radiation Exposure:

The radioactive decay of radium and its decay products results in the emission of highly penetrating gamma radiation. Gamma radiation is of concern because it can easily penetrate a few centimeters of soil to give anyone standing over a contaminated area a reasonably uniform irradiation over the whole body. The greater the duration or intensity of this exposure, the larger the dose, and hence the greater the risk of adverse health effects. In the case of the Open Space properties, the gamma radiation emission is limited to the area immediately above the contamination.

As discussed previously, EPA has determined that a significant increase in public health risk would result if any of the contaminated material on the Open Space properties was disturbed and misused or if any of the properties were redeveloped. If a building was constructed over the CSRR property, the most contaminated of the Open Space properties, the estimated annual dose to a person working in such a building would average 464 millirem per year (mrem/yr) with an estimated maximum annual dose of 3,819 mrem/yr. The estimated annual dose to a person living in such a building built over the CSRR property would average 1,518 mrem/yr with an estimated maximum

Table 2
PROJECTED CANCER RISKS
OPEN SPACE PROPERTIES
DENVER RADIUM SITE

<u>Scenario</u>	<u>Average Exposure</u>	<u>Average Cancer Deaths Per 10,000 Persons Exposed</u>	
Radon Decay Products:			
Building constructed over CSRR	1.46 WL	Workplace Residential	1400 to 4200 4700 to 7800
EPA Standard*	0.02 WL	Workplace Residential	23 to 91 130 to 500
Typical U.S. Home	0.005 WL	Residential	33 to 130
Gamma Radiation:			
Building constructed over CSRR	231 uR/hr	Workplace Residential	79** 330**
EPA Standard*	20 uR/hr	Workplace Residential	31** 53**
Background	15 uR/hr	Residential	27

* 40 CFR Part 192

** In addition to risk from exposure to background gamma radiation levels.

annual dose of 12,480 mrem/yr. These doses are in addition to the background dose of 130 mrem/yr incurred by those living in the Denver area and resulting from cosmic, terrestrial, and internal sources. The National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP) recommend a maximum allowable whole-body gamma radiation dose of 100 mrem/yr for members of the public in addition to natural background radiation and medical exposures they receive.

The projected cancer risk from gamma radiation (including background) to individuals working in such a building built over the CSRR property would average 79 cancer deaths per 10,000 persons exposed. The projected cancer risk to individuals living in the building would average 330 cancer deaths per 10,000 persons exposed. If individuals in any building were to receive a lifetime gamma radiation dose equivalent to that of the relevant and appropriate EPA standard, 40 CFR Part 192, then the projected cancer risk to those working in the building would average 31 cancer deaths per 10,000 persons exposed and the projected cancer risk to those living in the building would average 53 cancer deaths per 10,000 persons exposed. The average projected cancer risk to individuals receiving a lifetime dose resulting from the Denver area background would be 27 cancer deaths per 10,000 persons exposed. It should be noted that cancer risks resulting from gamma radiation exposure are in addition to those resulting from inhalation of radon decay products. Table 2 presents the information stated above.

Inhalation or Ingestion of Radiologically Contaminated Material:

Inhalation of the long-lived radionuclides like uranium, thorium, and radium is possible for persons living or working on or near the Open Space properties. Airborne particulate matter may contain small concentrations of these radionuclides resulting in a potential human exposure pathway. Inhalation or direct ingestion of long-lived radionuclides can result in significant doses to various internal organs of the body. However, studies by the United States Department of Energy have shown that the projected radiation doses from this source are many times smaller than those estimated for either radon decay product inhalation or direct gamma radiation exposure using even the most conservative assumptions. Also, it is unlikely that a person would ingest large amounts of the radium-contaminated material on the Open Space properties and dust control measures ordinarily employed during excavation have been shown to provide sufficient control of exposure from this source. For these reasons, EPA acknowledges the human exposure pathway resulting from inhalation and ingestion of radionuclides, but no quantitative risk numbers were developed in the Public Health and Environmental Assessment for the Open Space properties.

Ingestion of Nonradiologically Contaminated Soil:

The Public Health and Environmental Assessment quantifies risk to human health from ingesting soil containing low-levels of certain nonradiological carcinogenic contaminants which were found in discrete locations on the Allied and CSRR properties. For the Allied property, the average projected cancer risks from this type of exposure range from 0.034 to 0.10 cancer deaths per 10,000 persons exposed. For the CSRR property, the average projected cancer risks from this type of exposure range from 0.046 to 0.079 cancer deaths per 10,000 persons exposed. These risks are several orders of magnitude lower than the estimated risks resulting from exposure to the radiological contamination on the property. Nonetheless, the presence of nonradiological contaminants on the site will be explicitly considered in all health and safety provisions of the cleanup.

In summary, it is clear that a release or substantial threat of release of a hazardous substance or pollutant or contaminant into the environment has occurred at the Open Space properties and the release or threat of release may present an imminent and substantial endangerment to public health. It is also clear from the calculated risks that remedial action at the majority of the Open Space properties is justified.

Enforcement

A detailed responsible party search for the entire Denver Radium Site has been initiated. Regarding the source of contamination on the Open Space properties, records show the following. The radium-contaminated soil present on the CSRR property is apparently the result of a radium, vanadium, and uranium processing operation conducted by the National Radium Corporation, which occupied the property in 1926 and 1927. Radiological contamination on the DWD property is believed to be related to a facility operated by Radium Company of Colorado which was located on the nearby DuWald Steel property (an Operable Unit II property). Schlesinger Radium Company, a predecessor of the Radium Company of Colorado, operated a lab at 2001 East Colfax Avenue, the present day location of IHOP. The contamination present on Thomas Realty is suspected to have resulted from processing conducted by Rocky Mountain Radium Products Company. The responsible party search has yet to trace any of these companies or any associated companies to a viable, present-day entity.

Radium-contaminated material on the Allied property is thought to be contaminated fill that was brought in from an unknown downtown construction site during the early 1960s. The radiological contamination present at the Brannan property is suspected to be hospital waste. The sources of the radioactive materials present on the remaining Open Space properties have not been determined.

At this time, the responsible party search has not revealed that the present owners of the Open Space properties have any record of having been connected with the activities that caused their respective properties to be contaminated. EPA does not feel that response actions should be delayed pending finalization of the responsible party search. If, upon finalization of the search, responsible parties are clearly identified for a property, EPA will formally notify them of the selected remedy for that property and initiate negotiations for the implementation of the remedy. If the responsible parties do not formally commit to performing the remedy in a timely manner, EPA will proceed with a Fund-financed remedial design and remedial action and will attempt to recover EPA's response costs from the responsible parties.

Community Relations History

On August 13, 1987, the Proposed Plan for the Open Space properties was published in the Denver Post. On August 14, 1987, the Proposed Plan was published in the Rocky Mountain News. The display ads announced the August 14 through September 4, 1987, public comment period and the August 26 public meeting, gave a brief description of the remedial action alternatives, and stated the rationale for the Proposed Plan.

In addition to publishing the Proposed Plan, EPA issued a press release announcing the public comment period. The press release, along with the Executive Summary of the Open Space Properties FS, was mailed to the approximately 300 names on the EPA-compiled Denver Radium Site mailing list.

On August 7, 1987, EPA scheduled a meeting with the owners and tenants of the Open Space properties to describe and discuss the cleanup alternatives being considered for the properties. The owners and tenants who attended the meeting were interested in the details of remedial action, in particular, how remedial action activities would affect their business operations and if they would be compensated for any loss of business.

On August 26, 1987, EPA held a public meeting concerning the Open Space properties. Major concerns raised by those who attended the meeting were similar to those raised at the owners and tenants meeting, that is, how remedial action activities at the properties would affect the business operations of the owners and tenants and if they would be compensated for any loss of business. A second major concern raised at the public meeting was the liability of owners of contaminated properties. Another major concern raised during the public meeting was a question of why remedial action is so costly.

In general, the public supports the complete excavation and permanent offsite disposal of all Denver Radium Site material including the contaminated material present on the Open Space properties. The community has reservations about any temporary

response action which EPA may take at the Open Space properties because of concerns that the State of Colorado will not make available a permanent disposal site for this material and therefore, no permanent measures will ever be implemented at the Open Space properties. In addition, certain elected officials voiced concerns about selecting the No Action Alternative at some of the properties, in particular, Ruby Hill Park. The portion of the community in the vicinity of the Card Corporation property (See Figure 1) strongly opposes temporary storage of Open Space property material at the Card Corporation property, Operable Unit X of the Denver Radium Site, again because of concerns that the State of Colorado will not make available a permanent disposal site and that the temporary storage facility on the Card Corporation property will become permanent, resulting in a decrease in property values in the area.

The Responsiveness Summary attached to the Record of Decision contains the official transcript of the public meeting, describes in more detail the nature and level of the community's concern, and includes EPA's responses to all comments received during the public review of the Open Space Properties FS.

Alternatives Evaluation

EPA evaluated potential remedial action alternatives for the Open Space properties primarily by progressing through the series of analyses which are outlined in the National Contingency Plan (NCP), in particular, 40 CFR Section 300.68; the Interim Guidance on Superfund Selection of Remedy, December 24, 1986, (OSWER Directive No. 9355.0-19); and the Additional Interim Guidance for FY '87 Records of Decision, July 24, 1987, (OSWER Directive No. 9355.0-21). This process, in part, enables EPA to address the SARA Section 121 requirements of selecting a remedial action that is protective of human health and the environment, that is cost-effective, that attains Federal and State public health and environmental requirements that are applicable or relevant and appropriate, and that utilizes permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Additionally, SARA Section 121 and the guidance documents referenced above require EPA to give preference to remedies which employ treatment which permanently and significantly reduces the toxicity, mobility or volume of hazardous substances as their principal element.

The selection of remedy process begins by identifying certain site-specific information to be assessed in determining the types of response actions that will be considered for the properties. A general list of site-specific information to be considered in the process is contained in Section 300.68(e)(2) of the NCP. This list was used to identify specific site and waste characteristics of the Open Space properties. (See Tables 5-1 and 5-2 of the Open Space Properties FS.) Based upon these site and waste characteristics, EPA was able to scope, from the

universe of all possible response actions, a set of response actions and associated technologies to be considered for the Open Space properties. An example of this scoping process was the elimination from further consideration of onsite reprocessing on certain Open Space properties because these particular properties do not have sufficient area to construct a reprocessing facility. Appendix D of the Open Space Properties FS illustrates the scoping process and Table 5-3 of the Open Space Properties FS details the results.

Section 121(b)(1) of SARA requires that an assessment of permanent solutions and alternative treatment technologies or resource recovery technologies that, in whole or in part, will result in a permanent and significant decrease in the toxicity, mobility, or volume of the hazardous substance, pollutant, or contaminant be conducted. As part of this process, EPA evaluated permanent solutions to the problems associated with the specific hazardous substances present on the Open Space properties. The alternative treatment and resource recovery technologies considered included, among others, in-situ vitrification and reprocessing.

Before the technologies were assembled into remedial action alternatives, they were categorized as either source control or management-of-migration measures and then prescreened based on their suitability to abate the threat at the Open Space properties. Source control measures are intended to contain the hazardous substances onsite or eliminate the potential for contamination altogether by transporting the hazardous substances to a safer location. Management-of-migration actions are taken to minimize and mitigate the migration of hazardous substances. The result of the prescreening of both source control and management-of-migration measures based on their suitability to abate the threat at the Open Space properties is presented in Table 5-4 of the Open Space Properties FS.

The next step of the selection of remedy process is assembling the remaining technologies and/or disposal options into remedial action alternatives. Pursuant to OSWER Directive No. 9355.0-19, "Interim Guidance on Superfund Selection of Remedy", remedial action alternatives are to be developed ranging from those that would eliminate the need for long-term management (including monitoring) at the site to alternatives involving treatment that would reduce toxicity, mobility, or volume as their principal element. Remedial action alternatives developed in this way will vary mainly in the degree to which they rely on long-term management of treatment residuals or low-concentration wastes. Further, a containment option involving little or no treatment and a no action alternative are to be developed. Remedial action alternatives developed in the Open Space Properties FS were:

1. No Action (All properties)

2. Deferred Removal, Offsite Permanent Disposal (All properties)
3. Onsite Reprocessing/Treatment, Offsite Permanent Disposal (Allied and Brannan properties)
4. In-Situ Vitrification (Allied and Brannan properties)
5. Onsite Permanent Disposal (Allied, Brannan, and PSCo properties)
6. Offsite Permanent Disposal (All properties)
7. Onsite Temporary Land Storage, Offsite Permanent Disposal (Allied, Brannan, PSCo, and Thomas Realty properties)
8. Onsite Temporary Building Storage, Offsite Permanent Disposal (Allied, Brannan, PSCo, and Thomas Realty properties)
9. Onsite Temporary Containment (Capping), Offsite Permanent Disposal (All properties)
10. Temporary Building Storage at the Card Corporation Property (OU X), Offsite Permanent Disposal (All properties)

Alternatives 2, 3, 6, 7, 8, 9, and 10, since they require the permanent offsite disposal of contaminated material, would eliminate the need for long-term management (including monitoring) at the Open Space properties. Alternatives 3 and 4 involve treatment as their principal element, but do not necessarily reduce the mobility, toxicity, or volume of the waste. Alternatives 4 and 5 require permanent onsite remedies, and hence, long-term management and monitoring at the Open Space properties. Alternatives 5, 7, 8, and 9 are containment options - Alternative 5 requiring permanent onsite containment and Alternatives 7, 8, and 9 requiring temporary onsite containment. Finally, No Action was included as Alternative 1.

Alternative 6, Offsite Permanent Disposal, is not immediately implementable because the State of Colorado has not at this time designated a facility for the disposal of the Denver Radium Site wastes. Pursuant to CERCLA Section 104(c)(3)(C)(ii), it is the responsibility of the State to assure the availability of a disposal site. Also, in order to comply with SARA Section 104(k), and in order to assure that remedial actions within Colorado continue, the State must provide adequate assurance of the availability of a hazardous waste treatment or disposal facility within three years from the effective date of SARA, October 17, 1986. Although progress is being made to this end, the State does not expect to have a fully operational disposal facility prior to implementation of the remedial action and for up to five years. In the meantime, in its presently uncontrolled

state, the radium-contaminated material at the Open Space properties could be misused or inadvertently spread, possibly increasing the risk to present or future public health or the environment. In addition, the cost of final remedial action is expected to increase due to inflation; the Open Space property owners and tenants face economic losses associated with restricted use of their properties; and EPA may incur further cost by updating site studies in face of changing site conditions. For these reasons, EPA determined that, in order to effectively mitigate or minimize short-term threats to and provide adequate protection of public health and the environment at the Open Space properties, developing remedial action alternatives which include temporary response actions was appropriate. Thus, Alternatives 7, 8, 9, and 10 were developed to reduce existing risks by including temporary response measures followed by permanent offsite disposal of the contaminated material when a facility for such disposal becomes available.

Initial screening, which is the next step in the selection of remedy process, narrows the list of potential remedial action alternatives. Consistent with Section 300.68(g) of the NCP and the OSWER Directive No. 9355.0-19, the remedial action alternatives developed for the Open Space properties were initially screened using the criteria of cost, implementability (acceptable engineering practices), and effectiveness. Table 7-1 in the Open Space Properties FS summarizes the initial screening process. Alternatives 1, 2, 7, 8, 9, and 10 passed the initial screening and were carried forward for detailed analysis while Alternatives 3, 4, 5, and 6 were screened out primarily for the reasons set forth below.

Alternative 3, Onsite Reprocessing, which due to site conditions was only being considered for the Allied and Brannan properties, was eliminated from further consideration based on its lack of effectiveness. The residuals from this process, both the reprocessed soil and the concentrated precipitate resulting from the reprocessing of the soil, would require disposal in a facility that meets or exceeds the requirements of 40 CFR Part 192. These residuals would retain many of the toxicity and mobility characteristics of the untreated material and, in addition, the volume would not be significantly affected. This remedial action alternative would provide no additional benefit to public health or the environment over other remedial action alternatives to be considered.

Alternative 4, In-Situ Vitrification, which due to site conditions was only being considered for the Allied and Brannan properties, was eliminated during the initial screening because its implementability and effectiveness for this particular application is unproven. In-situ vitrification has not been demonstrated on a large scale or utilized in highly-populated urban areas like that of the Allied or the Brannan properties. A cap over the vitrified areas would be necessary to limit the escape of radon gas and; thus, this alternative does not affect toxicity or persistence of the contaminated material.

Furthermore, the Allied and Brannan properties would each have to be permanently dedicated as a disposal site and measures would have to be taken to prevent human contact with or disturbance of the vitrified material on both of the properties. Finally, this remedial action alternative would require long-term government ownership, licensing, management, and monitoring to protect the integrity of each cap and vitrified mass. These requisites would conflict with current and proposed land uses for the properties, as well as State policies on siting permanent disposal facilities, (6 CCR 1007-1, Part III, Schedule E, Criterion 1). The State siting objectives specify, among other things, that permanent disposal facilities must be located away from populated areas and that hydrogeologic and other environmental conditions be conducive to continued immobilization and isolation of contaminants from usable ground water sources. These criteria are clearly not met at the Allied and Brannan properties which are located within a metropolitan area, and where at the Allied property, for example, the depth to ground water is only approximately 10 feet.

With the elimination of these two remedial action alternatives, no remedial action alternative which involves treatment as a principal element survives the initial screening. However, EPA has no reasonable belief that either of these remedial action alternatives are equally protective as other remedial action alternatives, or offer the potential for better treatment performance or implementability, lesser adverse impacts, or lower costs than demonstrated remedial action alternatives.

Alternative 5, Onsite Permanent Disposal, which due to site conditions was only being considered for the Allied, Brannan, and PSCo properties, was eliminated from further consideration because of implementability and effectiveness factors. Each property would have to be permanently dedicated as a disposal site and measures would have to be taken to isolate the contaminated material from man and the environment for a thousand years without ongoing active maintenance. This objective would be difficult to attain in an urban area where there is a high potential for human disturbance and in an area where the ground water is fairly close to the surface as it is on these properties. This remedial action alternative would require long-term government ownership, licensing, and management and monitoring to protect the integrity of each facility. These requisites would conflict with current and proposed land uses for the properties, as well as State policies on siting permanent disposal facilities (6 CCR 1007-1, Part III, Schedule E, Criterion 1) discussed above.

Alternative 6, Offsite Permanent Disposal, which was being considered for all properties, is not implementable at this time because the State of Colorado has yet to designate a facility for the disposal of Denver Radium Site wastes. This alternative was therefore eliminated during initial screening.

The following is a description of the remedial action alternatives surviving the initial screening:

1. No Action (All properties)

If this remedial action alternative were selected, no action would be taken at the contaminated Open Space properties. This alternative serves as a baseline and was retained for further analysis and consideration as required by Section 300.68(f)(1)(v) of the NCP.

2. Deferred Removal, Offsite Permanent Disposal (All properties)

If this remedial action alternative were selected, removal of the contaminated material at the Open Space properties would be deferred until an approved offsite permanent disposal facility is identified and made available by the State of Colorado. Once this facility becomes available the contaminated material on the Open Space properties would be excavated and transported by either truck or rail for final disposal at this facility. The Open Space properties would then be available for unrestricted use.

7. Onsite Temporary Land Storage, Offsite Permanent Disposal (Allied, Brannan, PSCo, and Thomas Realty properties)

If this remedial action alternative were selected, contaminated material on the Allied, Brannan, PSCo, and Thomas Realty properties would be excavated and temporarily stored on each property, respectively. An asphalt pad would be constructed on an open area of each property. Contaminated material from each property would be placed on the pads and covered with a suitable material. Security precautions, inspections, and radiation monitoring of the land-storage facilities would be instituted. Once a suitable offsite permanent disposal facility becomes available, the contaminated material from each property would be transported by either rail or truck to the facility. The Allied, Brannan, PSCo, and Thomas Realty properties would then be available for unrestricted use.

8. Onsite Temporary Building Storage, Offsite Permanent Disposal (Allied, Brannan, PSCo, and Thomas Realty properties)

If this remedial action alternative were selected, contaminated material on the Allied, Brannan, PSCo, and Thomas Realty properties would be excavated and placed in containers. The containers would be temporarily stored in a newly constructed building on each property. Security precautions, inspections, and

radiation monitoring of the storage facilities would be instituted. Once a suitable offsite permanent disposal facility becomes available, the contaminated material would be transported by either rail or truck to the facility. Upon removal of the containers, the buildings would be decontaminated and either dismantled or left in place. The Allied, Brannan, PSCo, and Thomas Realty properties would then be available for unrestricted use.

9. Onsite Temporary Containment (Capping), Offsite Permanent Disposal (All properties)

If this remedial action alternative were selected, the identified areas of contamination on each Open Space property would be capped. Some of the Open Space properties, such as IHOP and the alley, already have asphalt caps in place. Restrictions on excavation would be required to limit disturbance of the caps. Security precautions, inspections, and radiation monitoring of the caps would be instituted. Once a suitable offsite permanent disposal facility becomes available, the contaminated material from each property would be transported by either rail or truck to the facility. The Open Space properties would then be available for unrestricted use.

10. Temporary Building Storage at Card Corporation Property (OU X), Offsite Permanent Disposal (All properties)

If this remedial action alternative were selected, the identified areas of contamination on each Open Space property would be excavated, the material placed in containers, and the containers transported to the Card Corporation Property (OU X) for temporary storage. The Open Space properties would then be available for unrestricted use. Security precautions, inspections, and radiation monitoring of the temporary storage facility on the Card Corporation property would be instituted. Once a suitable offsite permanent disposal facility becomes available, the contaminated material would be transported by either rail or truck to the facility. The Card Corporation property would then be available for unrestricted use.

Consistent with Section 300.68(h) of the NCP, the OSWER Directive No. 9355.0-19, and the OSWER Directive No. 9355.0-21, the remedial action alternatives remaining after initial screening were further refined and then subjected to detailed analysis. Detailed analysis of each remedial action alternative entailed evaluation based on the three broad criteria of implementability, effectiveness, and cost. For each of these broad criteria, EPA identified appropriate and more specific "component measures" so that the remedial action alternatives

could be compared to each other using a full array of evaluation factors. The component measures derived for implementability, effectiveness, and cost were based upon specific requirements and criteria contained in Section 300.68(h)(2) of the NCP, SARA Sections 121(b)(1)(A through G), SARA Section 121(c), the discussion on detailed analysis contained in the OSWER Directive No. 9355.0-19, and the OSWER Directive No. 9355.0-21.

The component measures of implementability are: technical feasibility, constructability, reliability, administrative concerns, availability of the technology, and operation and maintenance. The component measures of effectiveness are attainment of applicable or relevant and appropriate requirements (ARARs); effectiveness in significantly and permanently reducing mobility, toxicity, and volume; persistence, toxicity, mobility, and propensity to bioaccumulate of the hazardous substances and their constituents; protectiveness/health effects; environmental protectiveness/potential for adverse environmental impacts; and compliance with the Solid Waste Disposal Act. The component measures of cost are: capital cost, operation and maintenance costs, and potential future remediation costs if the alternative fails. Section 8 of the Open Space Properties FS provides a comparative review of the remedial action alternatives based upon each of the component measures listed above.

Implementability Analysis:

All of the alternatives which were analyzed in detail are technically feasible and constructable, are relatively easy to implement since they rely on readily available earth moving and construction technologies, and are operationally reliable. Removal of materials from around buried utilities will require special precautions. Each remedial action alternative except No Action and Alternative 2, Deferred Removal, Offsite Permanent Disposal, requires a limited degree of maintenance activities. No Action and Alternative 2 are administratively the easiest alternatives to implement. The need to coordinate and obtain access agreements with the Open Space property owners and the need to obtain necessary approvals and non-environmental construction permits from other offices and agencies are administrative implementation constraints common to all of the remedial action alternatives with the exception of No Action. Alternative 10, Temporary Building Storage at Card Corporation Property (OU X), Offsite Permanent Disposal, has an additional administrative implementation constraint, that is, an agreement with the Mentor Corporation, current owner of the Card Corporation property, to allow for storage of other Denver Radium Site wastes on the property must be finalized.

The necessary equipment and specialists for implementation of any of the remedial action alternatives are readily available. Remedial action work similar to that envisioned in the remedial action alternatives is already being safely conducted in Grand Junction, Colorado, under the auspices of the Uranium Mill Tailings remedial action Project. The final response action

associated with the remedial action alternatives, permanent offsite disposal, cannot be implemented until the State of Colorado provides a facility suitable for the disposal of this material. This implementation constraint is common to all of the remedial action alternatives analyzed in detail, except No Action.

Effectiveness Analysis:

Alternatives 7, 8, and 10 will meet contaminant-specific ARARs on those properties where target residual levels for radium in soils are currently being exceeded.¹ In addition, these three remedial action alternatives will meet all identified action-specific and location-specific ARARs and other guidance to be considered. Alternative 10 is more protective, and thus more effective, than either Alternative 7 or 8 because contaminated material, instead of being stored on the property, would be removed from the property entirely. Alternatives 2 and 9 are both less effective than either Alternative 7, 8, and 10 because Alternatives 2 and 9 will meet contaminant-specific ARARs only after the contaminated material from each property is removed to the offsite permanent disposal facility. Alternative 9, is in turn more protective, and thus more effective, than Alternative 2 because the cap will provide some limited short-term protection to public health and the environment, whereas Alternative 2, will provide absolutely no short-term protection to the public health and the environment until the material is removed. No Action will not meet the contaminant-specific ARARs on those properties where target residual levels are currently being exceeded and, therefore, will provide neither short-term or long-term protection of public health and the environment. The possible resulting exposure could result in unacceptable risks to public health and the environment.

No Action and, in the interim, Alternative 2 will not reduce the mobility, toxicity, or volume of the contaminated material on the properties. Although Alternatives 7, 8, 9, and 10 will not reduce the toxicity or volume of the radioactive waste, the contaminated material will be transferred from an uncontrolled status to a controlled facility or state, thereby reducing mobility. In addition, an increase in volume is often the result of the material being disturbed. Thus, Alternatives 7, 8, 9, and 10, since they reduce the chances of the material being

¹Target residual levels for radium in site soils have been established through one of the contaminant-specific ARARs for the Open Space properties, 40 CFR Part 192. This ARAR is discussed later in this report and in Section 4 of the FS. It does not appear that target residual levels are currently being exceeded at the Brannan property, Ruby Hill Park, and the alley, however, this premise will be confirmed during Remedial Design of the Open Space properties. See Table 3-1 in the FS for the radiological standards comparison for all of the Open Space properties.

disturbed, also may prevent the volume of contamination from increasing.

EPA conducted a Public Health Evaluation of Remedial Alternatives to determine short-term potential for adverse health effects from human exposure associated with the various remedial action alternatives. This analysis, summarized in Appendix F of the Open Space Properties FS, revealed that all of the alternatives considered except No Action would result in nearly equivalent exposures during implementation of the remedy. In addition, all estimated exposures would be well below target levels established in ARARs. EPA also conducted a Public Health and Environmental Assessment to determine the long-term potential for adverse health effects associated with the contaminant levels present on the Open Space properties. This analysis, summarized earlier in this summary and contained in Appendix B of the Open Space Properties FS, showed that there would be a significant increase in public health risk if the No Action alternative was implemented at the properties where contaminant-specific ARARs are currently being exceeded.

The potential for adverse environmental impacts at the Open Space properties is low. However, leaving the material on the properties in an uncontrolled state provides an opportunity for potential environmental impacts during a catastrophic event, such as a flood or water main break, resulting in a substantial dispersal of the contaminants.

Cost Analysis:

The cost analysis for the Open Space properties revealed that there is not a wide variation in costs among the remedial action alternatives for any given property. However, in general, for any given property the No Action Alternative is the least costly remedial action alternative followed by Alternative 2. For those properties where it is proposed, Alternative 8 is the most expensive remedial action alternative. For most properties, Alternative 10 is the next most expensive alternative. In general, Alternatives 7 and 9 have mid-range and similar costs. Tables 8-3 through 8-12 in the Open Space Properties FS present a breakdown of each alternative's cost for each property based upon the component measures of cost described above. An even more detailed breakdown of each alternative's cost is provided in Appendix G of the Open Space Properties FS. Section 8 of the Open Space Properties FS contains a sensitivity analysis of these costs.

In summary, the selected remedy for each property was chosen from the detailed analysis of alternatives. The analysis was based upon component measures of implementability, effectiveness, and cost. Table 3 outlines the detailed analysis of remedial action alternatives summarized above. (See also Section 9 of the Open Space Properties FS.)

Table 3

**SUMMARY OF ALTERNATIVE EVALUATION
OPEN SPACE PRIORITIES, RUBEN RADON SITE**

Evaluation Criteria	Alternative 3 No Action (All Properties)			Alternative 2 Deferred Removal/ Offsite Permanent Disposal (All Properties)		Alternative 1 Offsite Temporary Land Storage/ Offsite Permanent Disposal (Allied, FSO, Thomas, and Brannan Properties)	
	Feasible.			Sites could undergo additional development in contaminated areas. Contaminated materials could be dispersed or diluted such that they could no longer be identifiable.		Temporary storage can have technical problems, such as tipping of the synthetic liners or cracks in the asphalt pads.	
Implementability	Excavation cannot proceed until an off-site disposal facility is available. Availability required by SARA 104 (b). Facility is assumed not to be available until 1992.			While removal is deferred, containment-specific ARAR's may not be met. ARAR's would be met upon removal.		Temporary storage at the four properties would be used until offsite disposal facility is available. Availability required by SARA 104(b). Facility is assumed not to be available until 1992.	
	40 CFR 193 conditions for radium-226 in soils could not be attained at Allied, CSEB, IAD, FSO, CP No. 8, IIRF, and Thomas.			No action does not reduce mobility, toxicity, or volume of site radionuclides. However, the active materials are currently following properties are currently capped. IIRF, CP No. 8, Ruby Hill Park, the Allied, and IAD.		Site access restrictions and approvals at the four properties would be implemented to construct the asphalt pad storage units. Storage facilities would restrict usage of overall sites for 5 years.	
Effectiveness	MCRP/ICRP guidance may not be met at Brannan, Ruby Hill Park, and the Allied if exposure times exceed 4 hours per day, 350 days per year.			MCRP/ICRP gamma radiation values would be met. Removal and temporary onsite storage will not reduce toxicity and volume of radioactive wastes. The mobility of the material will be decreased for erosion aspects. A synthetic liner may not reduce the mobility of radon gas.		MCRP/ICRP gamma radiation values would be met. Removal and temporary onsite storage will not reduce toxicity and volume of radioactive wastes. The mobility of the material will be decreased for erosion aspects. A synthetic liner may not reduce the mobility of radon gas.	
	Radon active materials are extremely persistent. Radon is not very mobile and gives off radon decay products to the atmosphere. While not suitable after repurposing, radon is subject to dispersal via human activity. Radon decay products can accumulate in human lungs and are carcinogenic.						

Table 3
(cont.)

Evaluation Criteria	Alternative 1 No Action (All Properties)	Alternative 2 Deferred Removal/ Offsite Permanent Disposal (All Properties)	Alternative 3 Onsite Temporary Land Storage/ Offsite Permanent Disposal (Allied, PSCo, Thomas, and Brannen Properties)
Total Costs for Appropriate Properties	Not Applicable	Capital PW ^a --\$360,800 O&M PW--\$300,300	Capital PW ^a --\$380,200 O&M PW--\$337,300

During excavation, remedial action workers would be exposed to approximately 15 mrem/yr (whole body dose equivalent), which is below the 10 CFR 20 standard of 500 mrem/yr. Onsite workers who are not associated with cleanup would be exposed to approximately 1 mrem/yr, which is below the MCRP/ICRP guidance of 100 mrem/yr. Transportation of 350 miles to offsite disposal facility would involve driver exposure of 6.4 mrem/yr trip. Minimal exposure (0.007 mrem) would occur to general public during transportation, unless an accidental spill occurred, which would result in a minor increase in exposures. Disposal facility would be compliant with regulations that assure protectiveness of human health.

During excavation, remedial action workers would be exposed to approximately 17 mrem/yr (whole body dose equivalent), which is below the 10 CFR 20 standard of 500 mrem/yr. Onsite workers who are not associated with cleanup would be exposed to approximately 1 mrem/yr, which is below the MCRP/ICRP guideline of 100 mrem/yr. Transportation exposures would be identical to Alternative 2.

^aPW = present worth at a 10 percent discount factor.

^bO&M = Operations and Maintenance.

Table 3
(cont.)

Evaluation Criteria	Alternative 8 Onsite Temporary Building Storage/ Offsite Permanent Disposal (Allied, PSCO, Thomas and Branau Properties)	Alternative 9 Onsite Temporary Containment (Capping)/ Offsite Permanent Disposal (All Properties)	Alternative 10 Onsite Temporary Building Storage at Card Corporation (OU X)/ Offsite Permanent Disposal (All Properties)
Implementability	Synthetic bags or dumpsters could break open and spill material in the building. However, the building should contain any spilled materials. Temporary storage at the four properties would be used until offsite disposal facility is available. Availability required by SARA 104(k). Facility is assumed not to be available until 1992. Site access restrictions and approvals would be needed to construct the storage unit at the four properties. Storage facilities would restrict usage of properties for 5 years. Radium-226 levels in soils would be met upon initial removal.	Temporary containment can have technical problems, such as failure of the cap. Temporary containment at each property would be used until offsite disposal facility is available. Availability required by SARA 104(k). Facility is assumed not to be available until 1992. Site access restrictions and approvals would have to be implemented to construct the caps at the properties. The containment facility would restrict usage of the sites for 5 years.	Synthetic bags or dumpsters could break open and spill material in the building. However, the building should contain any spilled materials. Temporary storage would be used until offsite disposal facility is available. Availability required by SARA 104(k). Facility is assumed not to be available until 1992. Approvals for using the OU X property for radioactive material storage need to be obtained.
Effectiveness	Removal and temporary storage will not reduce toxicity and volume of radioactive waste. The mobility of the material would be decreased unless the container broke; however, the use of buildings for storing the containers would contain any spillage. The mobility of radon gas could be decreased, but could still present a problem within the container building used for storage.	Capping would not meet 40 CFR 192 and 10 CFR 20 standards for a permanent remedy. Removal and temporary onsite containment will not reduce toxicity and volume of radioactive wastes. The mobility of the materials will be decreased for erosional aspects.	Radium-226 levels in soils would be met upon initial removal. Removal and temporary containerization will not reduce toxicity and volume of radioactive waste. The mobility of the material would be decreased unless a container broke; however, the use of a building for storing the containers would contain any spillage. The mobility of radon gas could be decreased, but could still present a problem within the container building used for storage.

Table 3
(cont.)

Evaluation Criteria	Alternative 8 Onsite Temporary Building Storage/ Offsite Permanent Disposal (Allied, PSCO, Thomas and Beaman Properties)	Alternative 9 Onsite Temporary Containment (Capping)/ Offsite Permanent Disposal (All Properties)	Alternative 10 Onsite Temporary Building Storage at Card Corporation (On X)/ Offsite Permanent Disposal (All Properties)
Effectiveness (continued)	During excavation, remedial action workers would be exposed to approximately 35 mrem/yr (whole body dose Equivalent), which is below the 10 CFR 20 guideline of 500 mrem/yr. Onsite workers who are not associated with cleanup would be exposed to 1 mrem/yr, which is below the NCRP/ICRP guideline of 100 mrem/yr and the 40 CFR 190 standard of 25 mrem/yr at the facility boundary. Transportation exposures would be identical to Alternative 2.	During excavation, remedial action workers would be exposed to approximately 35 mrem/yr (whole body dose Equivalent), which is below the 10 CFR 20 standard of 500 mrem/yr. Onsite workers who are not associated with cleanup would be exposed to 1 mrem/yr, which is below the NCRP/ICRP guideline of 100 mrem/yr and the 40 CFR 190 standard of 25 mrem/yr at the facility boundary. Transportation exposures would be identical to Alternative 2.	During excavation, remedial action workers would be exposed to approximately 35 mrem/yr (whole body dose Equivalent), which is below the 10 CFR 20 guideline of 500 mrem/yr. Onsite workers who are not associated with cleanup would be exposed to approximately 1 mrem/yr, which is below the NCRP/ICRP standard of 100 mrem/yr. Transportation risks would be identical to Alternative 2.
Total Costs for Appropriate Properties	Capital PW--\$486,900 O&M PW--\$202,000	Capital PW--\$583,000 O&M PW--\$310,000	Capital PW--\$787,500 O&M PW--\$347,400

^aPW = present worth at a 10 percent discount factor.

^bO&M = Operations and Maintenance.

Selected Remedy

This Record of Decision addresses the contamination present on the Open Space properties. This is the seventh Record of Decision for the Denver Radium Site. EPA's selected remedy for each of the Open Space properties is described below.

Allied property:

EPA's preferred alternative for the Allied property is Alternative 6, Offsite Permanent Disposal. This alternative, however, was eliminated during the initial screening of remedial action alternatives because, until the State of Colorado provides a permanent disposal facility for material from the Denver Radium Site, this alternative cannot be implemented. EPA has therefore determined that the appropriate extent of remedy at the Allied property is Alternative 9, Onsite Temporary Containment (Capping), Offsite Permanent Disposal. The State of Colorado has been consulted and concurs with the selected remedy.

Remedial Design for the Allied property will include the selected remedy, Alternative 9, and EPA's preferred remedial action alternative, Alternative 6, Offsite Permanent Disposal. Should the State of Colorado fulfill its obligation to assure the availability of a suitable disposal facility for material from the Denver Radium Site by the time EPA has concluded Remedial Design for the Allied property, EPA may implement its preferred alternative, Offsite Permanent Disposal.

Brannan property, Ruby Hill Park, and the Alley:

EPA's selected remedy for the Brannan property, Ruby Hill Park and the alley is Alternative 1, No Action. According to the RI, it does not appear that the radium contamination in soils on these properties exceeds the target residual levels established in contaminant-specific ARARs for the Open Space properties. Additionally, unless extensive exposure periods occur, the limited amount of contamination on these properties would not result in exposures to the public exceeding the NCRP or ICRP guidelines for gamma radiation.

However, in the case of the alley, EPA makes the following recommendations:

1. That the City and County of Denver improve existing institutional controls so that all routine maintenance, repair, or construction activities in the alley carried out by government agencies, utility companies, contracting companies, private individuals, etc., will be monitored; and
2. That the City and County of Denver consider removing or requiring the removal of any contaminated material excavated during routine maintenance, repair, or construction activities in the alley to a facility approved for the storage or disposal of such contaminated material.

EPA believes these recommendations will more successfully be carried out if the alley is included in the institutional controls program for Streets, Operable Unit VII of the Denver Radium Site. The City and County of Denver is developing these institutional controls under a cooperative agreement with the State of Colorado.

Data on the Brannan property, Ruby Hill Park, and the alley will be reviewed during Remedial Design of the Open Space properties, and if necessary, additional data will be collected to confirm that the target residual levels are not being exceeded. If EPA determines that the costs of additional sampling for this purpose would exceed the costs of cleanup, or if the review indicates that target residual levels are exceeded, a remedial action alternative other than No Action may be implemented at these properties.

In the case of the Brannan property and the alley, Alternative 9, Onsite Temporary Containment (Capping), Offsite Permanent Disposal, will serve as the backup alternative. If future data evaluation indicates that target residual levels are being exceeded at Ruby Hill Park, or if the costs of additional sampling to make a determination exceed the costs of cleanup, then Alternative 10, Temporary Building Storage at Card Corporation Property (OU X), Offsite Permanent Disposal, will be implemented at the Park.

The State of Colorado has been consulted and concurs with the selected remedies and the backup remedies for the Brannan property, Ruby Hill Park, and the alley.

CSRR, DWD, PSCO, IHOP and Larry's, and Thomas Realty properties:

The EPA preferred alternative for these properties is Alternative 6, Offsite Permanent Disposal. This alternative, however, was eliminated during the initial screening of remedial action alternatives because, until the State of Colorado provides a permanent disposal site for material from the Denver Radium Site, this alternative cannot be implemented. EPA has therefore determined that the appropriate extent of remedy for these properties is Alternative 10, Temporary Building Storage at Card Corporation Property (OU X), Offsite Permanent Disposal.

Remedial Design for these properties will include the selected remedy, Alternative 10, and EPA's preferred remedial action alternative, Alternative 6, Offsite Permanent Disposal. Should the State of Colorado fulfill its obligation to assure the availability of a suitable disposal facility for material from the Denver Radium Site by the time EPA has concluded Remedial Design for these properties, EPA may implement its preferred alternative, Offsite Permanent Disposal. The State of Colorado has been consulted and concurs with the selected remedies for these properties.

Description of the Selected Remedies:

The selected remedy for the Allied property, and the backup remedies for the Brannan property and the alley, is Onsite Temporary Containment (Capping), Offsite Permanent Disposal. This alternative consists of one temporary management-of-migration response action followed by one final and permanent source control response action. The temporary management-of-migration response action at the Allied property consists of placing a cap over the identified areas of contamination which cover approximately 4,320 square feet of the Allied property and account for an estimated 290 cubic yards of contaminated material. The cap at the Allied property (or the Brannan property or alley if this alternative is implemented as a backup) will temporarily limit the spread of the contaminated material by wind and water erosion and human activity. The cap will also provide temporary protection of human health by reducing direct exposure to gamma radiation and by reducing the risk of inhalation or ingestion of contaminated soil. Placement of the cap could take one to three months. The cap will be routinely inspected and restrictions on excavation will be instituted to maintain the integrity of the cap. The cap will remain in place until a permanent offsite disposal facility becomes available.

The final and permanent source control response action at the Allied property (or the Brannan property or the alley if this alternative is implemented as a backup) will occur once a permanent offsite disposal facility becomes available and consists of removing the cap and excavating the material which was temporarily placed under the cap. This material and any portion of the cap which is contaminated would then be transported by either truck or rail to the permanent offsite disposal facility. Excavation of the contaminated material under the cap and transportation of the material to the permanent offsite disposal facility could take three to six months. A more detailed implementation schedule for this response action and the one described above will be developed during Remedial Design.

The selected remedy for the CSRR, DWD, PSCo, IHOP and Larry's, and Thomas Realty properties is Alternative 10, Temporary Building Storage at Card Corporation Property (OU X), Offsite Permanent Disposal. This alternative consists of one temporary source control response action followed by a final and permanent source control response action. The temporary source control response action consists of removing the estimated 1020 cubic yards of contaminated material from these properties, placing this material in containers, and transporting the containers to the Card Corporation property, Operable Unit X of the Denver Radium Site, for temporary storage until an offsite permanent disposal facility becomes available. Removal of the contaminated material from these properties could take one to two months.

The final and permanent source control response action will occur once a permanent offsite disposal facility becomes

available and consists of transporting the material stored at the Card Corporation property by either truck or rail to the offsite permanent disposal facility. The temporary storage facility on the Card Corporation property would then be decontaminated and, if necessary, dismantled and the material transported to a solid waste landfill. A detailed implementation schedule for this response action and the one described above will be developed during Remedial Design.

The present-worth cost of the selected remedy for the Allied property is \$143,600 based upon a ten-percent interest rate, a five-year discount period, and a perpetual monitoring period. The cost of this alternative includes placement of the cap over the contaminated area, and maintenance and monitoring of the Allied property for a period of five years. This cost also includes removal and transportation of the capped material and any portion of the cap which may be contaminated to the offsite permanent disposal facility when one is available.

The present-worth cost of the selected remedy for the Brannan property and the alley depend upon whether future data evaluation indicates that target residual levels are exceeded resulting in the backup alternatives being implemented. If instead of No Action, Onsite Temporary Containment (Capping), Offsite Permanent Disposal, is implemented at the Brannan property, the present-worth cost would be \$68,500. If this remedial action alternative is implemented at the alley, the present-worth cost would be \$41,000. The cost of this alternative includes costs for the activities itemized above for the Allied property.

If No Action is implemented at the alley, the State of Colorado and the City and County of Denver may accept EPA's recommendation of including the alley as part of the institutional controls program being designed for Streets, Operable Unit VII of the Denver Radium Site. EPA has already awarded Superfund Cooperative Agreement funds for this purpose and consistent with CERCLA Section 104(c)(3), the State of Colorado and the City and County of Denver will be responsible for assuring the payment of all future costs of maintaining and operating the institutional controls, including proper disposal of any contaminated material excavated during routine maintenance, repair, or construction activities in the alley.

The present-worth costs of the selected remedy for Ruby Hill Park depend upon whether future data evaluation indicates that target residual levels are exceeded resulting in the backup alternative being implemented. If instead of No Action, Temporary Building Storage at Card Corporation Property (OU X), Offsite Permanent Disposal, is implemented at Ruby Hill Park, the present-worth cost would be \$92,900. This cost includes excavation of the contaminated material from the Park, placement of the material into containers, transfer of the containers to the Card Corporation property, placement of the containers within the temporary storage facility, and maintenance and monitoring of

the containers and temporary storage facility for a period of five years. The cost of this alternative also includes removal and transport of the contaminated material from the storage facility to the offsite permanent disposal facility, decontaminating and, if necessary, dismantling the temporary storage facility at the Card Corporation property, and transporting the decontaminated material to a solid waste landfill. The costs are based upon a ten-percent interest rate, a five-year discount period, and a perpetual monitoring period.

The selected remedy for the CSRR, DWD, PSCo, IHOP and Larry's, and Thomas Realty properties is Temporary Building Storage at Card Corporation Property (OU X), Offsite Permanent Disposal. The present-worth cost of the selected remedy for each of the properties is as follows:

CSRR	\$126,800
DWD	150,600
PSCo	94,000
IHOP	130,700
Larry's	93,600
Thomas	147,600

These costs include costs for the activities itemized above for Ruby Hill Park. The costs are based upon a ten-percent interest rate, a five-year discount period, and a perpetual monitoring period.

Operation and maintenance activities will be required to ensure the effectiveness of the temporary response actions associated with the selected remedies. These activities include site inspections, ongoing radiological monitoring, and possible minor repairs to the cap on the Allied property or the temporary storage facility on the Card Corporation property. Also included as an operation and maintenance activity for cost estimating purposes is a review of the properties which, pursuant to SARA Section 121(c), must be conducted no less than every five years if a remedial action is selected that results in any hazardous substances remaining onsite. Since EPA does not anticipate that any hazardous substances will remain onsite longer than five years, the cost of this review is considered a contingency. Operation and maintenance costs are included with the present-worth total alternative cost mentioned above.

Statutory Determinations:

Protectiveness: The Public Health and Environmental Assessment for the Open Space properties summarized earlier in this document clearly shows that there would be a significant increase in the risk of contracting lung and other cancers if Alternative 1, No Action, was selected for those Open Space properties where radium concentrations in soils exceed the target residual levels, and the properties were ever developed in a way which might reasonably be expected. The only effective way to

reduce this risk on those Open Space properties where target residual levels are exceeded is excavation to achieve target residual levels and removal of the contaminated material from the properties to an offsite permanent disposal facility. Further, because the offsite permanent disposal facility would be designed to isolate the contaminated material from man and the environment for a thousand years, the selected remedy for these particular properties would provide long-term protection of public health and the environment. The temporary measures envisioned in the selected remedy will provide the necessary short-term protection of public health and the environment.

In addition to preparing the Public Health and Environmental Assessment mentioned above, EPA conducted a Public Health Evaluation of Remedial Alternatives, summarized in Appendix F of the Open Space Properties FS. For this evaluation, exposures to gamma radiation, inhalation of contaminated soils, and inhalation of radon decay products were estimated for persons who might be exposed to hazards during implementation of each alternative undergoing detailed analysis. These persons include onsite remedial action workers, individuals not associated with remedial activities but working in an onsite office, residents of a home located outside of the property boundary, a transportation worker, and an onlooker present during truck transportation of the contaminated materials. Exposures were calculated for each remedial action alternative undergoing detailed analysis other than No Action. The evaluation revealed that none of the estimated exposures for any scenario of any remedial action alternative, including the selected remedies, exceeded exposure limits set by the relevant and appropriate standard or guideline. Also, for any given scenario, there was no appreciable difference among the estimated exposures for the remedial action alternatives. The risks associated with this type of remedial action work lie not with possible radiological exposure, but with the inherent dangers associated with general construction work. Based upon statistics from the construction industry, EPA estimates that the number of non-fatal injuries to cleanup workers would range from 0.013 to 0.056 for the type of work to be conducted during remedial action at the Open Space properties and the number of fatalities would range from 0.001 to 0.006. (See report entitled Open Space Properties, Public Health and Environmental Assessment, Dose Commitments.) These numbers can be significantly reduced by hiring competent and properly trained construction contractors and by strict adherence to the site safety plan.

The OSWER Directive No. 9355.0-19 states, "Remedies must be protective of human health and the environment. This means that the remedy meets or exceeds ARARs..." EPA has determined that the selected remedies for each property will meet all ARARs identified for the Open Space properties. For this reason and from the analyses conducted in the Public Health and Environmental Assessment and the Public Health Evaluation of Remedial Alternatives and because of the permanence associated with the design of the offsite disposal facility, EPA has

concluded that the selected remedies for each property would be protective of public health and the environment once the permanent offsite disposal component of the selected remedies has been implemented.

Consistency With Other Laws: Pursuant to SARA Section 121(d), remedial actions shall attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and control of further release which at a minimum assures protection of human health and the environment. In addition, remedial actions shall, upon their completion, reach a level or standard of control for such hazardous substances, pollutants, or contaminants which at least attains legally applicable or relevant and appropriate Federal standards, requirements, criteria, or limitations, or any promulgated standards, requirements, criteria, or limitations under a State environmental or facility siting law that is more stringent than any Federal standard (ARARs).

On November 20, 1986, EPA requested that the State of Colorado identify potentially applicable or relevant and appropriate State public health and environmental requirements for the Card Corporation property (OU X). The State responded to this request on January 21, 1987, with a list of Colorado requirements which pertained to the entire Denver Radium Site.

EPA classified all Federal and State public health and environmental requirements applicable or relevant and appropriate to the Open Space properties into three categories: contaminant-specific ARARs, action-specific ARARs, and location-specific ARARs. A description of each of these categories is provided in both Section 4 and Appendix C of the Open Space Properties FS. Other Federal and State criteria, advisories, and guidance were also considered. Tables C-1 through C-4 in Appendix C of the Open Space Properties FS contain a brief description of each potential Federal and State requirement identified and EPA's analysis of each requirement's applicability or relevance and appropriateness to the Open Space properties. EPA has determined that each selected remedy will meet all applicable or relevant and appropriate public health and environmental requirements of Federal and State laws and, therefore, no SARA Section 121(d)(4) waivers need be invoked. A brief discussion of ARARs for the Open Space properties is provided below.

The EPA Standards for remedial action at Inactive Uranium Processing Sites, 40 CFR Part 192, are one of two contaminant-specific ARARs identified for the Open Space properties. For properties contaminated with uranium processing residues, these standards establish limits for the gamma radiation level and annual average radon decay product concentration in any occupied or habitable building and for the radium concentration in soil on open lands. Although not necessarily applicable to the Open Space properties since the standards apply only to certain specifically designated sites where uranium was processed, the standards are relevant and appropriate to the Open Space

properties because (1) it is the radium content of the uranium mill tailings which is regulated; (2) the waste products resulting from uranium ore processing are very similar to those from both radium and vanadium ore processing; (3) the residues from both processes enter the environment through the same exposure pathways; and (4) the adverse health concerns resulting from exposure to the residues from both processes are the same.

The portion of the standards relevant and appropriate to the contaminated soil on the Open Space properties and the portion which serves as EPA's target residual level for cleanup is 40 CFR Section 192.12 which states:

"Remedial actions shall be conducted so as to provide reasonable assurance that, as a result of residual radioactive materials from any designated processing site:

- (a) the concentration of radium-226 in land averaged over any area of 100 square meters shall not exceed the background level by more than -
 - (1) 5 pCi/g, averaged over the first 15 centimeters of soil below the surface, and
 - (2) 15 pCi/g, averaged over 15 centimeter-thick layers of soil more than 15 centimeters below the surface."

(40 CFR Section 192.12)

The second contaminant-specific ARAR identified for the Open Space properties is the Nuclear Regulatory Commission Standards for Protection Against Radiation, 10 CFR Part 20. These regulations establish standards for protection against radiation hazards arising out of activities under licenses issued by the Nuclear Regulatory Commission (NRC). Because these standards apply to licensed NRC facilities, they are not applicable to the Open Space properties. However, EPA has determined that portions of the regulations are relevant and appropriate to individuals who would be conducting the remedial action on the Open Space property. In addition, these regulations are incorporated by reference in the Occupational Safety and Health Administration Standards, 29 CFR Parts 1910 and 1926, which, due to the mandate contained in SARA Section 126, now apply to employees involved in responses covered by CERCLA.

Of particular importance is Appendix B of 10 CFR Part 20 which provides limits for airborne concentrations of natural uranium, thorium-230, and radium-226. Gamma radiation dose standards for individuals in restricted and unrestricted areas are cited in 10 CFR Sections 20.101 and 20.105, respectively. These 10 CFR Part 20 standards along with the 40 CFR Part 192 standards are summarized in Table 4.

EPA has identified one potential location-specific ARAR for the Open Space properties, the Executive Order on Flood Plain

Table 4
POTENTIAL CONTAMINANT-SPECIFIC ARAR'S
OPEN SPACE PROPERTIES, DENVER RADON SITE

Regulatory Agency	Type of Contaminant	Standard, Requirement, Criteria, or Limitation	Comments
FEDERAL			
U.S. EPA-40 CFR 192, Subpart B-Standards	Radium-226 Concentration	5 pCi/g above background within 15 cm of the surface measured over a 100-m ² area 15 pCi/g above background within subsequent 15 cm layers measured over a 100-m ² area	Standards for cleanup of soils; concentration of radium-226 in land, averaged over any area of 100 square meters. Point of compliance is at any contaminated area greater than 100 m ² . However, during cleanup all contaminated areas would be remediated.
	Gamma Radiation ^a	20 μ R/hr above background	Relevant and appropriate to indoor gamma radiation. Point of compliance is inside any site building.
	Radon Decay Product Concentration	0.02 WL annual average 0.03 WL maximum	Relevant and appropriate to indoor radon. Point of compliance is inside any site building.
Nuclear Regulatory Commission (NRC) 10 CFR 20	Uranium-natural Airborne Concentrations	5 pCi/m ³ Unrestricted area ^b 100 pCi/m ³ Restricted area ^c	Point of compliance is any location within site.
	Thorium-230 Airborne Concentrations	3 pCi/m ³ Unrestricted area ^b 30 pCi/m ³ Restricted area ^c	Point of compliance is any location within site.
	Radium-226 Airborne Concentrations	3 pCi/m ³ Unrestricted area ^b 30 pCi/m ³ Restricted area ^c	Point of compliance is any location within site.
	Gamma radiation ^a	5 rem/yr, (5,000 mrem/yr) Restricted area ^c 500 mrem/yr, Unrestricted area	Point of compliance is any location within site; site would be unrestricted for remediation workers.

^a Relevant and appropriate standard but not as protective as Other Guidance; see Table 4-3.

^b An unrestricted area is regarded as any place around a waste consolidation/storage area facility where access is not controlled.

^c A restricted area is regarded as any place around a waste consolidation/storage area where access is controlled.

Management, 40 CFR Section 6.302(b), which requires Federal agencies to evaluate the potential effects of actions they may take in a flood plain to avoid, to the maximum extent possible, the adverse impacts associated with the direct and indirect development of a flood plain. Remediation of the contamination on certain Open Space properties which lie in a flood plain, the Allied and DWD properties, is not likely to have an adverse affect in the event of a flood especially since having the contaminated material in a controlled state will reduce the chance that contaminated material would be spread during a flood. As mentioned previously, although the Brannan property lies within a flood plain, it does not appear that target residual levels are currently being exceeded and, therefore, No Action is the selected remedy for this property. Currently, there are no identified State location-specific ARARs for the Open Space properties.

Action-specific ARARs are technology-based restrictions triggered by specific types of remedial measures under consideration. Once the remedial action alternatives were developed in the Open Space Properties FS, EPA identified specific action elements which were part of at least one or more of the alternatives. These action elements are listed in Section 6 of the Open Space Properties FS. EPA then identified numerous action-specific ARARs for each of the action elements. These action-specific ARARs were evaluated in Appendix C of the Open Space Properties FS and are presented in Table 6-2 of the Open Space Properties FS.

In addition to the ARARs mentioned above, EPA also considered other Federal and State criteria, advisories, and guidance in determining the appropriate degree of cleanup for the Open Space properties. In particular, EPA considered the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP) recommendation for maximum gamma radiation dose to the whole body. This dose, 100 mrem/yr, is for chronic exposure to the general public, excluding natural background and medical radiation. This recommended level is more protective than the level established by the NRC in its regulations (10 CFR Part 20), and will be used in evaluating exposures to those working on the site but who are not associated with remedial cleanup of the Open Space properties.

SARA Section 121(d)(3) codifies EPA's offsite disposal policy, which requires that offsite disposal of any hazardous substances, pollutants, or contaminants from a Superfund site take place only at a facility that is in compliance with applicable Federal law and all applicable State public health and environmental requirements. Furthermore, the unit to which these wastes are transported must not be releasing any hazardous waste or constituent to ground water, surface water, or soil, and any such releases from other units at the facility must be controlled by an approved corrective action program. It is incumbent upon the State of Colorado, as part of its CERCLA requirements, to

assure the availability of a disposal facility which is in compliance with EPA's offsite disposal policy.

Cost-effectiveness and Utilization of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable: Alternative 10, Temporary Building Storage at Card Corporation Property (OU X), Offsite Permanent Disposal, is a cost-effective remedial action alternative for the CSRR, DWD, PSCo, IHOP and Larry's, and Thomas Realty properties. This alternative effectively mitigates and minimizes threats to and provides adequate protection of public health and the environment. This remedial action alternative will result in the removal of contaminants from these properties to achieve target residual levels and will eliminate the need for long-term management at these properties, freeing these properties for unrestricted use. These results cannot be achieved by the methods envisioned in any of the other remedial action alternatives considered for these properties.

The selected remedy for the Brannan property, Ruby Hill Park, and the alley is No Action. Since it does not appear that the target residual levels of radium in soils are being exceeded at any of these properties, remedial action is not necessary, and therefore, No Action is cost-effective.

Alternative 9, Onsite Temporary Containment (Capping), Offsite Permanent Disposal, is a cost-effective remedial action alternative for the Allied property. This alternative effectively mitigates and minimizes threats to and provides adequate protection of public health and the environment. Although the temporary building- or land-storage facilities envisioned in Alternatives 7, 8, and 10 may be slightly more protective than the cap conceived of in Alternative 9, EPA believes the temporary cap will provide the necessary short-term protection for the Allied property especially in light of the low level of activity on the property and the access controls which already exist on the property.

The selected remedies will address the principal threat at the Open Space properties. However, the selected remedies do not satisfy the statutory preference for treatment as a principal element. As part of the selection of remedy process, EPA evaluated permanent solutions to the hazards associated with the specific substances present on the Open Space properties. However, since the hazardous substance associated with the Open Space properties is a radioactive element, the number of treatment technologies which may successfully reduce the mobility, toxicity, and volume of the hazardous substance is extremely limited. The characteristic of spontaneously emitting energy and subatomic particles is a property inherent to each atom of a radioactive element and which cannot be altered or destroyed by any chemical or physical treatment known today. Most treatment and resource recovery technologies concentrate the radioactive elements present in the waste, increasing toxicity

without sufficiently reducing volume or mobility. These treatment and resource recovery technologies will leave a waste product which is still radioactive. Nonetheless, EPA considered several treatment and resource recovery technologies in the technology scoping and screening phase and even the initial alternative screening stage of the Open Space Properties FS. However, no technology was found which would result in a permanent and significant decrease in the toxicity, mobility, and volume of the hazardous substance, radium, which is present on the Open Space properties.

Future Actions

The future remedial activities that are required to complete remedial action at the Open Space properties are:

- (1) Design remedial actions including confirmatory sampling needed to verify whether "No Action" is an appropriate response at the Brannan property, Ruby Hill Park, and the alley.
- (2) Enter into State Superfund Contract with State of Colorado.
- (3) Conduct temporary remedial actions for contamination present on Open Space properties.
- (4) Select and, if necessary, design and construct permanent disposal facility. (This activity is to be conducted by State of Colorado.)
- (5) Remove contaminated material from the Allied property and the temporary storage facility on the Card Corporation property and transport to permanent disposal facility.
- (6) Confirm that the Open Space properties have been decontaminated to conform with the requirements of ARARs and can be made available for unrestricted use.

Schedule

Dates for completing key milestones leading to remedial action at the Open Space properties are highlighted below:

- (1) Complete design of remedial actions by September 30, 1988.
- (2) Finalize State Superfund Contract with State of Colorado by September 30, 1988.
- (3) Initiate remedial actions no later than during first quarter fiscal year 1989.